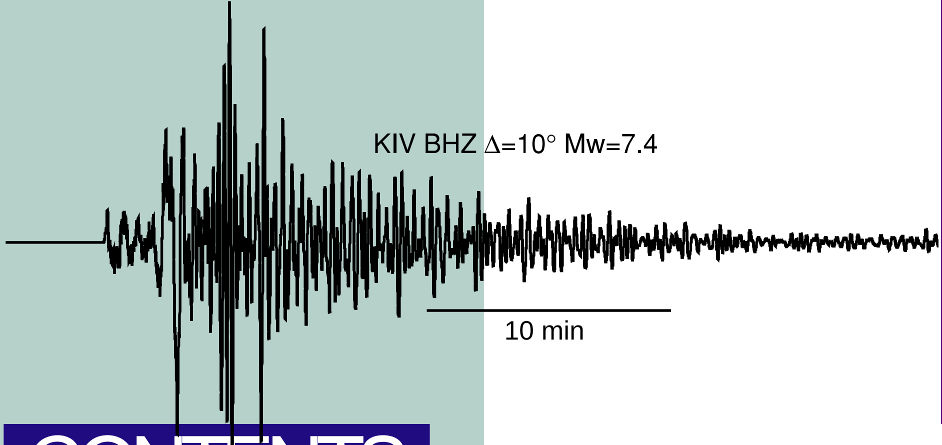



IRIS NEWSLETTER

VOLUME XVIII ■ NUMBER 1

CONTENTS

SPRING/SUMMER 1999



# Planet Earth On-Line

Low-cost, high-bandwidth, global communication systems are ushering in a new era for seismology. We now design personal global data streams, assemble virtual seismic networks, and analyze local ground motion in real-time from across the planet. Network operators remotely monitor data collection and, with only a few keystrokes, can re-center the mass on a seismometer buried within a vault thousands of miles away. In museums and classrooms, students watch seismic waves propagate around the world as interactive global seismicity maps inform them of earthquakes within minutes of their occurrence.

This IRIS Newsletter features articles that describe real-time data systems and several of their applications. In many ways, these articles mark the change of emphasis in our data-driven science from collection to selection. The next generation of seismologists will have global data available in real-time at nominal cost. Many researchers need never know (nor for that matter particularly care) about the mechanics of how data are being collected and transmitted, let alone how the stations are installed, operated and maintained. For them, the new challenge will be the coherent integration and use of these vast and continually evolving streams of sensor data. ■

**Real-time data are collected at Toro Peak in southern California from remote seismic stations using radio telemetry for PASSCAL Broadband Array tests and the ANZA Broadband Seismic Network operations. The data are sent through the Internet using the microwave link shown in the photo.** **[photo: G. Offield]**

# Live Seismograms from the Net

***Charles R. Hutt and Harold Bolton***
***USGS Albuquerque Seismological Laboratory***

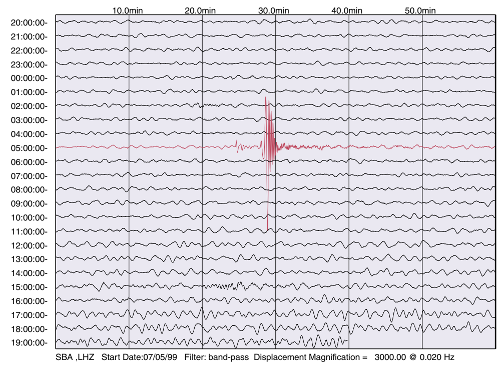



**Figure 1. The 24-hour seismogram was plotted from 1 sample-per-second seismic data from the GSN station at Scott Base, Antarctica (SBA) collected in near real-time by the LISS running at ASL. The regional $M_b$ 4.6 event, seen on the plot, occurred near the Balleny Islands on July 6, 1999, at a distance of 16.2 degrees.**

Live seismic data are now available on the Internet. Both Data Collection Centers of the Global Seismographic Network (GSN) have developed near real-time servers that make data from GSN stations directly available. Both types of data servers are known by their acronyms:

LISS - Live Internet Seismic Server was developed by the USGS Albuquerque Seismological Laboratory (ASL);

NRTS - Near Real-Time System was developed by the University of California, San Diego (see following article).

Although this article concentrates on the LISS, NRTS has similar functionality.

## Seismographic Networks

ASL currently operates about 75 GSN stations and the UCSD IDA group approximately 33 GSN stations. Both of these numbers are growing as the two groups expect to complete the installation of a total of about 150 GSN stations over the next 2–3 years. This will complete the installation phase of the GSN, developed by IRIS. (Figure 2)

Near real-time data are now available from many of these GSN stations. The LISS operating at ASL currently collects data from 36 GSN stations (Figure 2). The data from these stations can be obtained from the LISS in raw digital form (miniSEED) and are displayed at the LISS web site as heliplots covering the past 24 hours. The number of stations with near real-time data is increasing as connections to stations via the Internet and satellite links become more widely available. There are also plans to include near real-time data via the LISS from the US National Seismic Network (USNSN) stations in the near future.

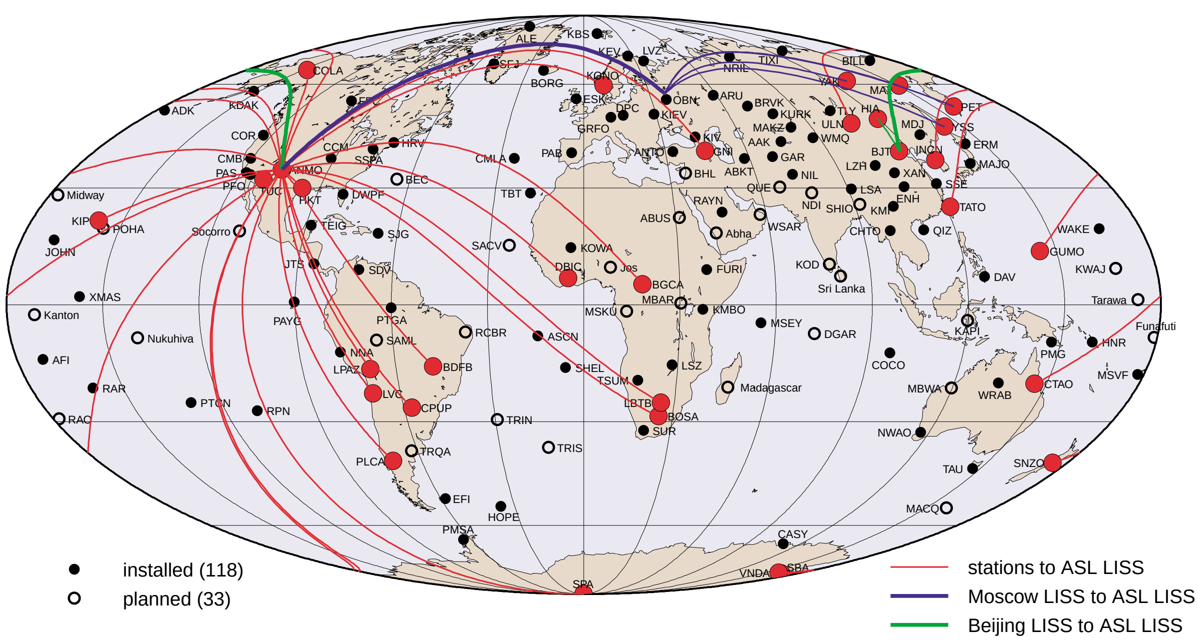



**Figure 2. The ASL LISS currently provides data from 36 stations of the GSN (plotted as red circles). Data from Chinese and Russian stations are received by the LISSes in their respective countries, and then served to the primary LISS located in Albuquerque, New Mexico (as indicated by the heavy green and blue lines).**

**Figure 3. ASL field engineer Neil Ziegelman performs maintenance on radio telemetry equipment at Vanda Station, Antarctica (VNDA). This type of telemetry link is commonly used at remotely located seismograph stations to send real-time data to the LISS.**

## What can you use it for?

**Internet Surfing:** Heliplots (as in Figure 1) emulate the appearance and function of the old standard WWSSN photographic paper seismograms that were created by writing a trace of magnified ground motion on a long piece of paper wrapped around a drum. These heliplots are available on the LISS website to anyone with access to a computer, a web browser and Internet connectivity. In addition to the seismograms, the LISS website includes a world map showing the earthquakes of the past 24 hours as reported by the USGS National Earthquake Information Center (NEIC). The heliplots and map are updated every 30 minutes, so it is easy for seismo-surfers to keep themselves informed of the world's current seismicity. There are also links to other informative earthquake oriented websites, including sites displaying live seismic data and related educational material.

**Seismic displays:** The LISS provides a near real-time (1-3 minutes delay) source of waveforms from GSN stations for several public seismic displays that are connected via the Internet. These seismic displays are generally equipped with an Internet connected computer and receive live data streams from several GSN stations that are displayed on analog drum recorders. Such a display strikes a chord with the general public, since a live moving pen on a drum recorder seems more like a "real" seismogram than a computer display. IRIS and ASL have, in fact, cooperated in producing several of these displays, one of which is operating at IRIS headquarters (Figure 4). Similar displays are operating at the New Mexico Museum of Natural History and Science in Albuquerque, NM, at the American Museum of Natural History in New York, and at the Carnegie Museum of Natural History in Pittsburgh. In addition, the first seismic display developed and built as a cooperative effort by IRIS, ASL, and the NM Museum of Natural History, is currently touring the US as part of the Franklin Institute's "Powers of Nature" exhibit.

**Professional use:** The use of LISS data by seismologists is still in its infancy. It is not exactly clear what directions may ensue, but many practical applications are in use or in development. The LISS has the ability to maintain a large number of simultaneous connections, to any or all of the data collected. This allows for an unprecedented amount of versatility in the projects that are designed to use the data. An obvious application is real-time monitoring. These data can provide for quicker and more accurate earthquake source information and are ideal for hazards groups such as the USGS NEIC and tsunami warning centers. Already being constructed are 'virtual networks' (see related article on page 7) where workers are able to collect data from a subset of stations that enhance the specific goals of individual projects. These data are also proving to be invaluable to the individual Data Centers as a tool to enhance quality control (QC). Rather than having to wait (sometimes up to several months) for data tapes to be mailed from stations in the field to the Data Centers, the QC analyst can, at a glance, detect overt problems (Figure 5) at a station and initiate the appropriate corrective actions.

## How the LISS works, How to connect

The primary LISS site is currently

**Figure 4. Robert Woodward discusses global seismicity using a LISS seismicity display at IRIS headquarters in Washington, DC.**

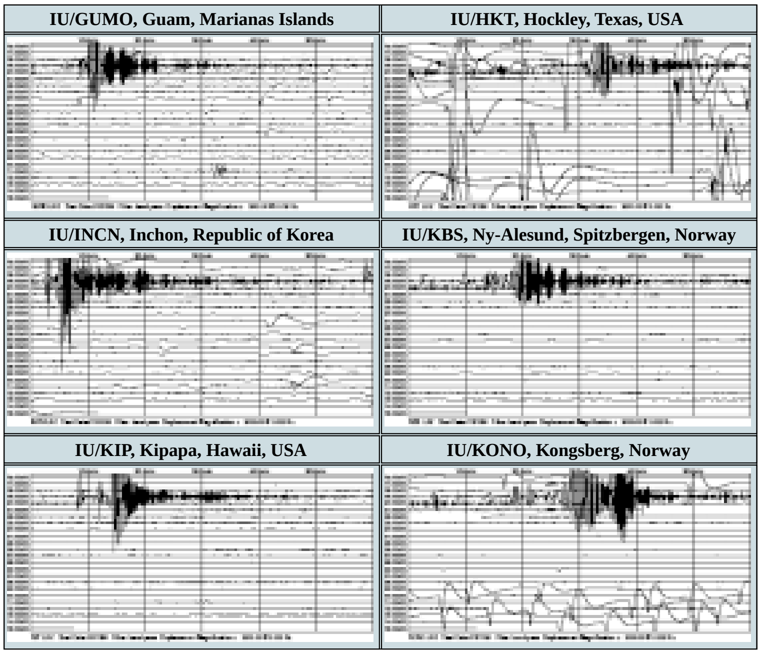



**Figure 5. "Thumbnails" from six of the 35 heliplots available on the LISS website. Stations HKT and KONO have transients that can be easily identified by a quality control analyst scanning for station problems.**

located at the USGS Albuquerque Seismological Laboratory. ASL will soon have a secondary LISS located at another site with much higher bandwidth capabilities. This change should be transparent to the user. The most basic feature of the LISS is that it can provide many users access to the data from a single station while only the LISS server is actually connected to the station (Figure 6). As the LISS can connect to many stations, its versatility is greatly enhanced. Currently, the LISS pulls over the entire set of channels from a station which has been preprogrammed by the station's software engineers. If one LISS site were to die, it would then be possible to turn on another LISS site to gather each station's data without having to reprogram each individual station. The broadband miniSEED data records from each station typically contain about 30 seconds of data. Each station has a record ready to be pulled about 120 seconds after the initial record is acquired. The LISS servers then broadcast these records to any clients connected to the LISS server.

All the software and documentation that are necessary to connect to the LISS are free and available to anyone willing to download them from the LISS web site. Currently the software has been tested on Solaris and FreeBSD platforms and, if demand warrants, could be extended to various Linux and perhaps Windows systems. Users are encouraged to use and adapt the software in any manner they wish.

## Future Directions

Second generation LISS software is currently under active development at ASL. A primary goal of this development will be to have redundant LISS servers that can be automatically switched for load leveling and as backup should there be a primary failure. Also to be included are the use of user 'select files' for choosing which stations and channels are to be received. Other features will be driven by user requests. The LISS source code will be freely made available for development work.

Additional information on LISS connectivity and current global seismicity can be found at the LISS website http://www.liss.org ■

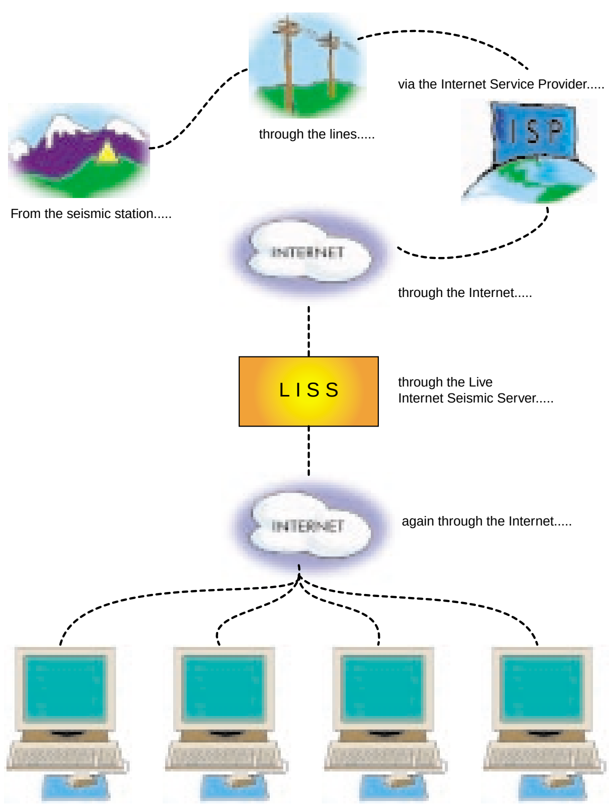



**Figure 6. Data flow diagram of the LISS connected to a single seismograph station while serving several users. The LISS actually connects to many stations simultaneously, as well as to other LISS servers.**

# The IDA Near Real-Time System

***Peter Davis, Jon Berger and David Chavez***
***University of California, San Diego***

For the past seven years, the University of California, San Diego (UCSD) has used the Near Real-Time System (NRTS), a body of software developed at UCSD with funding from IRIS, to collect IRIS GSN data over the Internet.

In September 1992, NRTS was first used to telemeter data from the Kislovodsk miniarray back to a data collection center in Obninsk, Russia, and from there to San Diego. Since then, the software has undergone major revision and has matured into a robust system, capable of acquiring data from a variety of stations. NRTS is now used by the US Geological Survey's National Earthquake Information Center (NEIC), and the National Oceanographic and Atmospheric Administration's (NOAA) tsunami warning centers in Hawaii and Alaska. The IRIS Data Management System requests made by the IRIS SPYDER® system use NRTS' AutoDRM capabilities. The two IRIS/IDA stations that are also part of the Comprehensive Test Ban Treaty's International Monitoring System use NRTS to transmit data to the US National Data Center.

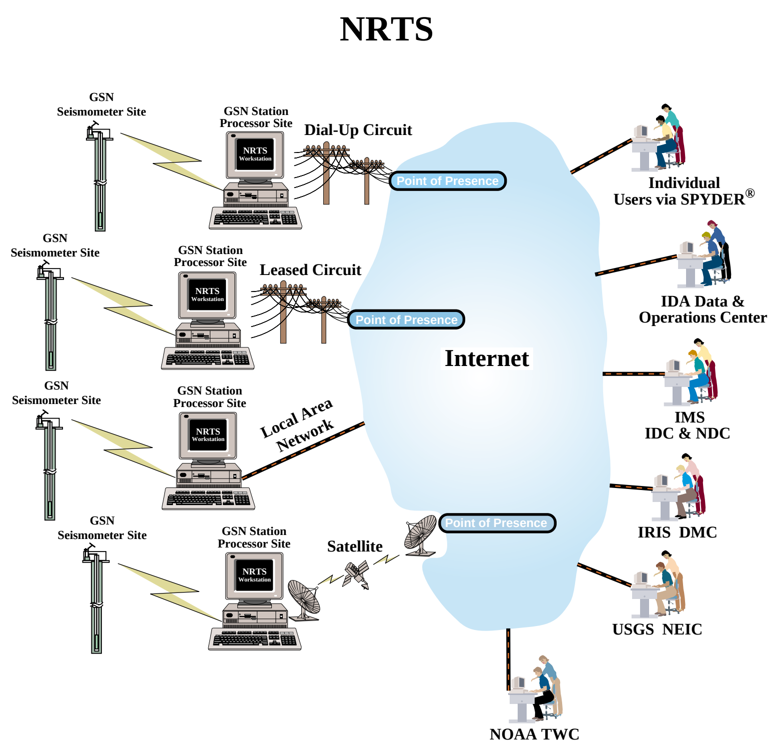



**Figure 1. Schematic representation of IDA NRTS architecture. Data acquired from geophysical instruments at a field site are fed into a Solaris workstation. From there, the data are available to users on the Internet by way of TCP/IP connections via telephone circuit (either analog or digital) used in either dialup or continuous (leased) mode; satellites; or on a local area network (LAN). Once on the Internet, data can be easily accessed by individual investigators and organizations interested in monitoring seismic activity in near real-time. The system is actively used by agencies charged with monitoring earthquakes, clandestine nuclear tests, and tsunamis.**

From its inception, NRTS was designed to meet the many requirements for communicating with a GSN station, where "last kilometer problems" often come into play. For example, power is usually at a premium at GSN stations, and can be subject to frequent interruption. Also, the bandwidth of the circuit to the station is often severely limited, and high communications costs create the need to reduce connectivity to minutes per day. With these and similar restrictions in mind, NRTS was designed around the TCP/IP protocol suite, and can thus use the Internet and its associated long-haul telecommunications infrastructure. By basing data acquisition and transmission upon the TCP/IP protocols, the task of connecting to a remote location is reduced to the task of bringing the Internet to the station — a problem for which a multitude of off-the-shelf solutions exist. Additionally, the application software on both ends of the circuit can be designed without the need for knowledge of the details of the communications links. As a consequence, the NRTS data management framework permits robust recovery from interruptions in communications links. The problem of restricted bandwidth is alleviated by node replication at NRTS hubs located where connectivity is less bandwidth-limited. All of these features are very important at GSN stations, which tend to lie at the very periphery of the cyber universe.

## System Architecture

NRTS runs on any POSIX compliant UNIX platform. It accepts a data stream as input, writes the data to a disk loop, and then services data requests from that loop. Once in the loop, data may be requested, either in segments or continuous feeds, in miniSEED, SAC, CSS, or GSE (Alpha or Beta) formats. If a continuous feed is requested, those data are passed on with little additional latency. Each packet input to the NRTS host is immediately output by the data request server.

A computer running NRTS may be configured either as a station host or as a hub. A station host accepts data locally and stores that data within a disk loop of configurable length, and is limited only by disk size. The host's data server can satisfy requests for any data retained within that disk loop. At many UCSD

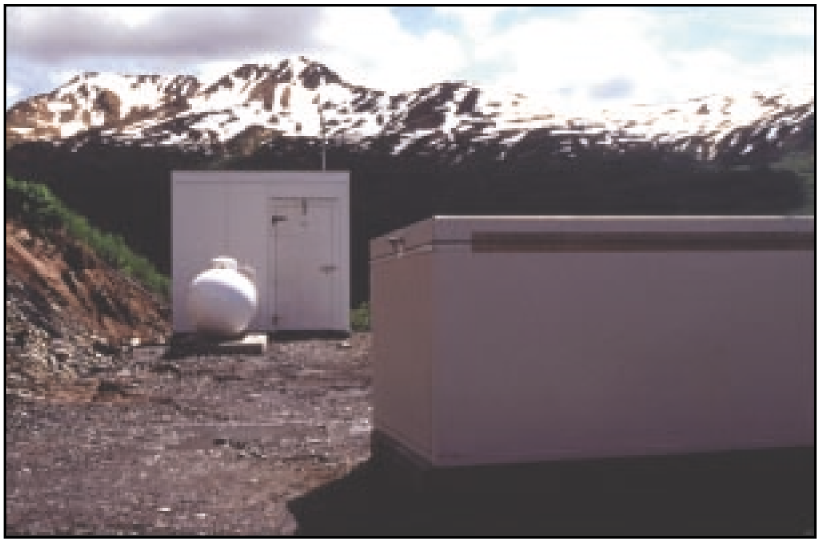


**Figure 2. Photo of IRIS/IDA station KDAK (Kodiak, Alaska), one of the US IMS seismic stations. In the foreground is a cover to protect the wellhead, and in back, a shed housing recording equipment. The round object in front of the shed is a tank containing propane fuel for the station's thermoelectric generator.**

stations, the loop length is set to one week. A hub accepts data feeds from one or more station hosts. The hub's data server may accept all or part of the data available from a given station host. The amount of data transferred to the hub is only limited by the bandwidth and cost of the circuit connecting host and hub. There are currently three principle NRTS hubs: one at UCSD in La Jolla, one in Obninsk, Russia, and one at IRIS in Washington, DC.

Data requests may be directed to either a hub or a station host. If a hub's data server cannot satisfy a request from data already transmitted to that hub, then the data server consults an ordered list of NRTS data servers known to handle data from the desired station(s). These servers may be running either on the station host or on other NRTS hubs. In cases where the circuit to a station is bandwidth limited, it is desirable to direct data requests first to the hub rather than the station. All requests that can be satisfied at the hub are fulfilled from there, and only those data not at the hub already are requested from the station, thus avoiding duplicate transmission.

## The KDAK Example

Telemetry from station KDAK (Kodiak, Alaska) is a good example of how the NRTS manages data retrieval over a complicated circuit. All data recorded on site are sent via spread spectrum radio to a PC at a Coast Guard facility three kilometers away. NRTS running on the PC stores the data and retransmits a portion over a leased telephone line to a Sun workstation at the University of Alaska, Fairbanks. NRTS on that Sun stores the data and retransmits to a number of users around the world over the Internet. The bandwidth of the telephone leg is insufficient to transfer all data recorded at KDAK. Data not routinely transmitted over the above circuit may be obtained by sending AutoDRM requests to IDA's server, idahub.ucsd.edu. NRTS retrieves the requested segments and returns data to the user via email.

> "The recipient need never know (nor care) about the details of how data are retrieved from a station halfway around the world."

## Future Developments for NRTS

During the coming year, IDA expects to establish telemetry to most of the remaining stations not yet reachable. As additional circuits are put in place and the bandwidth of existing circuits are broadened, more data than ever will be available in near real-time. The architecture of NRTS is well designed to accommodate these changes. In fact, a few changes to configuration files are all that are required to convert management of a bandwidth-limited dialup circuit that handles only low rate and state-of-health data to one that handles continuously the entire output of a GSN station.

As projects such as EarthScope make telemetered data even easier for end-users to access, the node replicating capabilities of NRTS will come into full play. Data will be routinely copied to nodes that can be easily accessed thus preventing the circuit over "the last kilometer" from being overwhelmed servicing requests. The recipient need never know (nor care) about the details of how data are retrieved from a station halfway around the world. ■

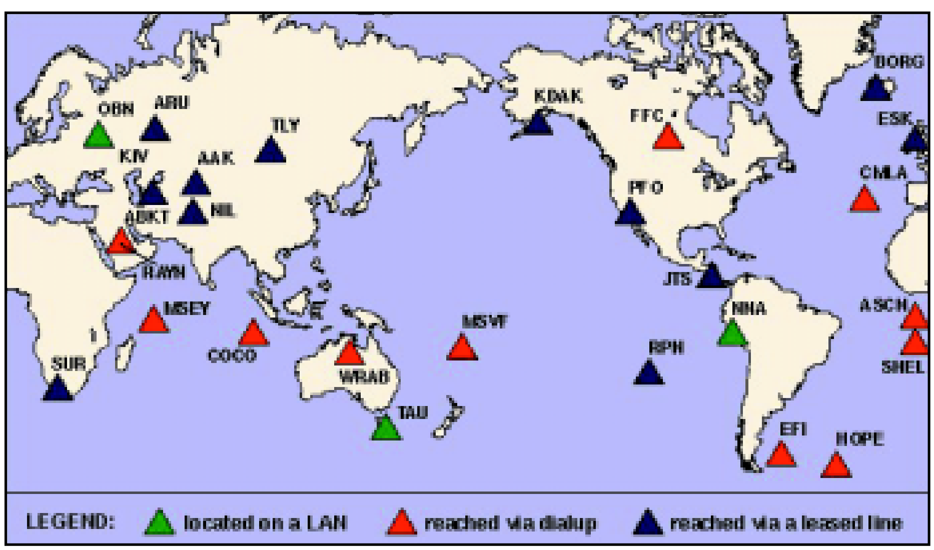



**Figure 3. IRIS/IDA seismographic stations currently accessible via telemetry.**

# Virtual Seismic Networks

***Frank Vernon, University of California, San Diego and***
***Terry Wallace, University of Arizona***

Seismology is an opportunistic science where many significant results are achieved by a combination of good planning and hard work coupled with a strong component of serendipity. Take for example the recent results generated by data recorded from the deep Mw = 7.6 Fiji and Mw = 8.2 Bolivia earthquakes and associated aftershocks in 1994. The high quality data recorded by the permanent IRIS GSN stations was certainly caused by good planning, while the fortuitous recording by local PASSCAL experiments was by virtue of a lot of luck.

The GSN and PASSCAL datasets currently provide most of the broadband data used in seismological research, although this situation will be evolving in the future as data from permanent regional and national broadband stations become more widely available. The 1999 deep Mw = 7.1 Russia-China border event, which did not have a co-located PASSCAL experiment, was well recorded by the Kyrgyz Broadband Network (KNET), the Austrian National Seismic Network, and many other regional and national networks. Many of the data for these events were available almost immediately through the Internet.

GSN stations routinely send data back to their respective data collection centers in San Diego and Albuquerque using the NRTS and LISS real-time data delivery systems. The GSN currently includes facilities in more than 80 countries. On a national scale, twenty-three IRIS member universities, along with the USGS, operate real-time regional seismic networks in every seismically active region in the United States (http://www.cnss.org). These networks range from the large aperture University of Alaska network (with nearly 300 stations covering all of Alaska including the Aleutian Islands) to the smaller local networks, such as the Montana Regional Seismic Network.

The most striking characteristic of the global distribution of seismographic stations is it’s incredibly heterogeneous nature. Many agencies from many countries support the complex infrastructure. These different agencies have missions that range from seismic monitoring to detailed hazard assessment at local levels. They are all united, however, by the data they collect.

The transmission of real-time data from seismic field stations to a primary data collection center is being done in a variety of ways according to each network’s specific mission and based on unique hardware, communication systems, number of stations, and areal coverage requirements. While each individual network may have different missions and use different types of

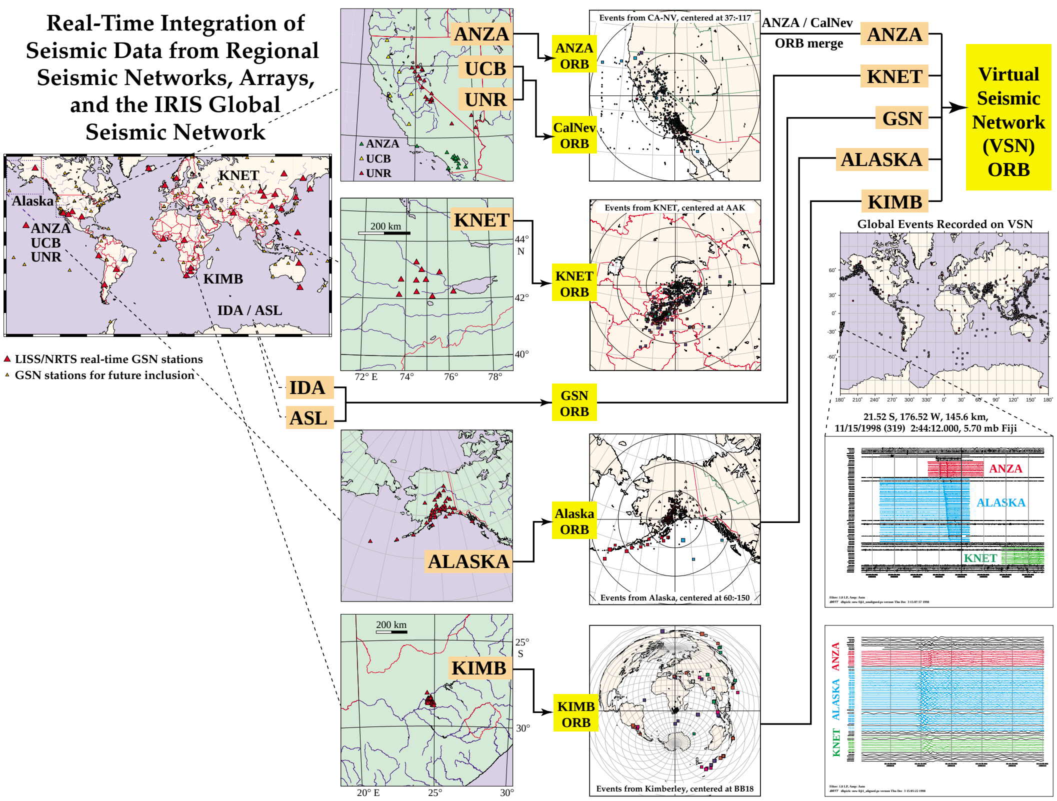



**Figure 1. A feasibility test to collect data from seven different regional and global seismic networks and integrate them into a “Virtual Seismic Network”. Maps on the left show station locations with the name of each network. Data from each network are processed to produce epicentral locations which are shown on the maps on the right. Collated seismograms from an earthquake near Fiji, recorded on the VSN, are shown on the two waveform plots in the lower right.**

equipment, all network data centers have one thing in common: access to the Internet. With this existing infrastructure, we can now consider the integration of all accessible real-time data.

Starting at the end of 1998, we conducted a feasibility test for real-time data integration from multiple disparate seismic networks to create a "Virtual Seismic Network" (VSN). In the test, data from the IRIS GSN network, the PASSCAL Broadband Array, four US regional networks (University of Alaska, UC Berkeley, UC San Diego, and University of Nevada, Reno), and the Kyrgyzstan National Broadband Network were integrated into one common data processing system (Figure 1). This test successfully demonstrated that over 150 seismic stations from seven different primary data collection centers could be accessed through the Internet and processed in real-time. The level of processing accomplished during the test included: data assembly, automated phase picking, event location, and display of event location and magnitude information. In a parallel development, the USGS at Golden has developed their "Virtual Data Logger" as a mechanism to use real-time data from many network data sources to build their global catalog.

The VSN is ushering in a new era in seismology where global data are available to any researcher in real-time at nominal cost. But, how will the "real-time" era change seismology? The most immediate impact is that individual researchers will be able to design experiments which will be able to maximize existing resources. For example, if a scientist is interested in operating a portable experiment in Chile, they can construct their own virtual network from the global inventory of stations that maximizes the monitoring capability for that region of interest. Individual researchers can also receive *continuous* data streams (not event segmented), which means that new discoveries will be made which in the past would have been most likely unexamined (if you don't see it, how can you order it from the DMS?).

"The VSN is ushering in a new era in seismology where global data are available to any researcher in real-time at nominal cost."

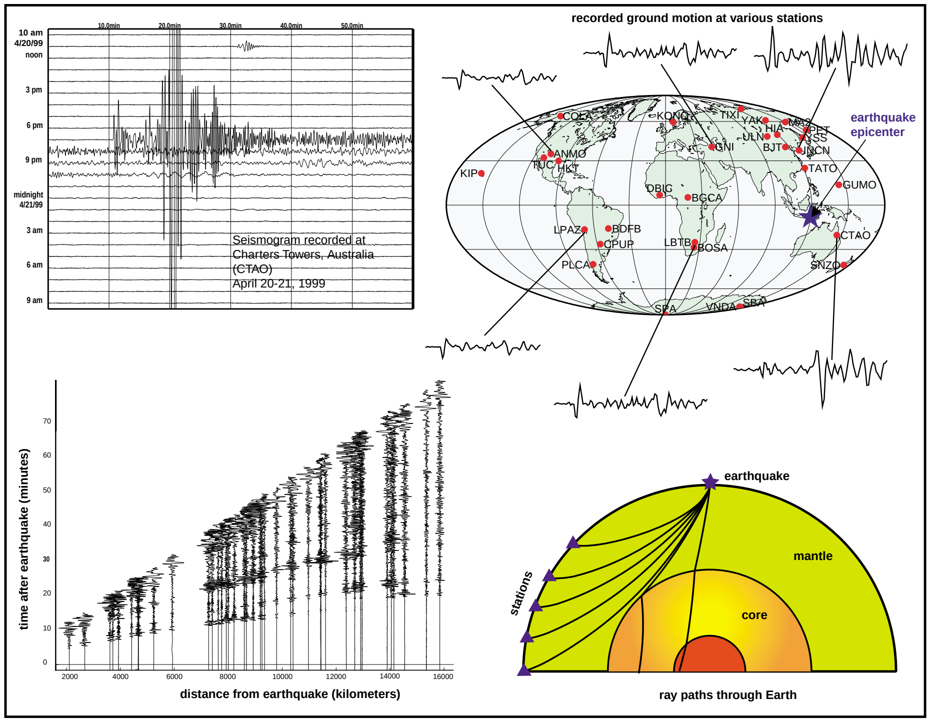



**Figure 2. The seismogram in the upper left is a helicorder style plot showing a full day's record at Charters Towers in Australia, showing the motions caused by a significant earthquake in Indonesia. The record section in the lower left is from the same earthquake recorded at many stations around the world. The cross-section of the earth gives a representative sample of ray paths. The map in the upper right show the location of the event and samples of the first part of the seismogram at selected stations.**

The following are two examples that show the utility of customized "VSNs":

*Network 1: Study of the physics of deep focus earthquakes.*

An experiment could use several broadband regional networks as seismic arrays to form continuous beams on regions were deep earthquakes occur. The network would have the advantage of observing smaller events than the current global catalogs record, provide much finer relative locations between events, and yield significant information about the rupture properties of the larger events.

*Network 2: Designing a real-time seismicity module for an Earth science course.*

Students could be allowed to design their own seismic networks using Internet-available stations. The virtual networks could be used, for example, to study a currently active aftershock region. Figure 2 shows a project which presents the record section views of seismograms, showing the source and site locations with a cross-section of the Earth for large teleseisms.

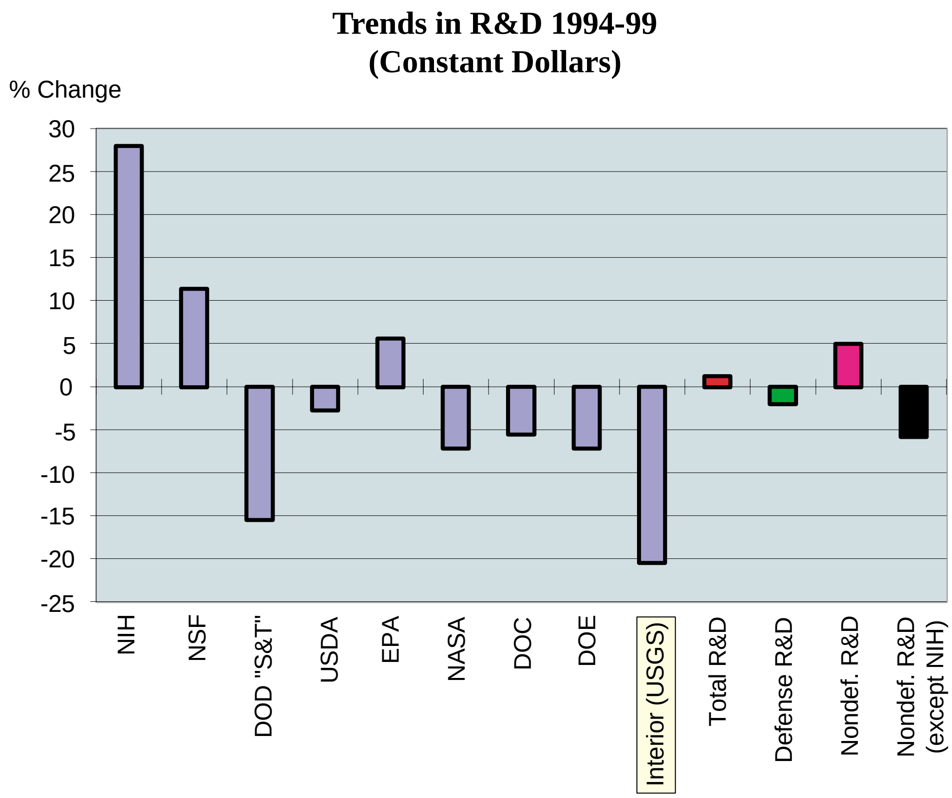
This is unquestionably only the beginning. As more scientists obtain access to real-time data streams it is to be expected that entirely new functions will be devised to extract more information from these data in real-time as they design their own Virtual Seismic Networks.

## Acknowledgments

Bob Woodward provided Figure 2. The seismic networks operated by the University of Alaska, University of California at Berkeley, University of Nevada, Reno, the IDA project at UCSD and USGS Albuquerque Seismic Lab, kindly provided access to their real-time waveform data. ■

# Building Support for the Geosciences

***David Applegate***
***American Geological Institute***




**Percentage Change of Federal Research and Development Funding in Constant Dollars, Fiscal Years 1994-1999. [source: AAAS]**

Scientists are well practiced in presenting a strong rationale for their research when competing for grants, making the case for why the research is important and how it will advance the state of knowledge in their field. They are much less practiced at providing the public, and particularly their elected representatives, with a similarly convincing case for funding the agencies that distribute those grants.

Science enjoys broad public support based on a general perception that it has helped bring about improved quality of life. That support, however, is as shallow as it is broad, and cannot be relied upon when science must compete with many other worthy programs for scarce dollars when federal budgets are tight. If public support is to continue and hopefully grow, scientists must work with partners in industry and government to put forward focused and convincing rationales for why their research improves people's lives.

An inherent strength of the geosciences is the direct relevance to a wide range of resource, environmental, and natural hazard-related issues that affect people's everyday lives. And yet, geoscientists have fallen behind their counterparts in other disciplines in their ability to attract federal support. In particular, funding for the principal geoscience agency in the federal government — the US Geological Survey (USGS) — has lagged behind that of other science agencies in recent years.

To change this situation, geoscientists need to hone their arguments for the political arena with the same care that they do in their research proposals. Perhaps the most promising rationale that geoscientists can use is natural hazard mitigation, an area where the costs are high and the potential benefits from geoscience research are great.

## Political Rationales for Science

Since the second World War, economic growth, human health, and national security have been the basis for justifying federal science. Since the end of the Cold War, however, national security has faded as the dominant rationale, replaced by human health. A look at the percentage change in various federal science agencies over the past five years tells the story (see figure above). In that time period, the budget for research and development (R&D) at the National Institutes of Health (NIH) has increased nearly 30 percent in constant dollars, while R&D spending by the Department of Defense (DOD) dropped over 15 percent. Among the other major civilian science agencies, only the National Science Foundation (NSF) and the Environmental Protection Agency (EPA) posted gains. Overall, civilian R&D spending rose 5 percent, but if one removes NIH from the calculation, it actually dropped 6 percent.

## What Rationales Work for Geoscience?

If NIH and NSF have been the big winners in recent years, science at the Department of the Interior has been the biggest loser, faring considerably worse than any other agency or department, including Defense.

Why is the USGS — now the lone science bureau at Interior — lagging so far behind? There are two principal reasons, both of which are also applicable to the broader question of why the geosciences in general are lagging. The first is simply the lack of awareness in Congress of what the Survey does. When the new Republican majority in Congress called for the Survey's abolition in 1995, it did so because the USGS appeared to be an obscure agency without a visible constituency.

Second, it has proven difficult to use the economic growth and human health rationales to justify geoscience projects and programs. The geosciences are most closely identified with the energy and mineral sectors, neither of which are viewed as growth sectors.

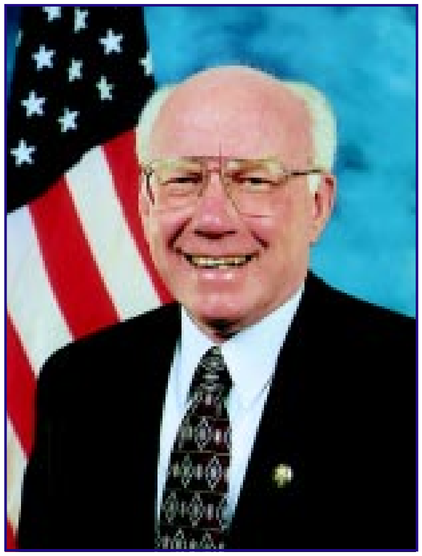
Successfully employing a human health rationale for the geosciences poses the even larger challenge of translating the overwhelming public concern for the environment into a demand for better scientific understanding of the Earth and its processes.

If the traditional rationales for science are not working for the geosciences, then clearly new justifications are required. Last year, the House of Representatives endorsed a new national science policy developed by Science Committee Vice-Chair Rep. Vern Ehlers (R-MI), a former physics professor. Ehlers calls for augmenting the traditional rationales for science with one described as "helping society make good decisions," particularly when it comes to environmental issues, where all sides are calling for a sound scientific base for decision-making. This rationale is particularly relevant to the geosciences and to agencies like the USGS where scientific expertise is separated from regulatory or land management authority.

A very different rationale that can be employed is the wonder factor, which underpins much of the support for space research and astronomy. The geosciences also have tremendous sources of wonder in the processes of our own dynamic planet, including the apocalyptic punctuations to Earth history and the volcanic eruptions and earthquakes that still inspire awe in our modern times.

## The Case for Natural Hazards

Both of the alternative rationales above suggest what is potentially the most compelling rationale for the geosciences, one that encompasses all of the other rationales in a single issue area — mitigating natural hazards.



**Science Committee Vice-Chair Rep. Vernon Ehlers (R-MI) science policy study argued that "helping society make good decisions" should be a key rationale for federal investment in science.**

For geoscientists involved in environmental or resource activities or in fundamental research, a natural hazards rationale may seem unrelated to their interests. But when it comes to justifying the geosciences to the public and policy-makers, geoscientists will sink or swim as a group. Disciplinary distinctions tend to fall away when it comes to public perception. If geoscientists as a community can communicate the value of their work in natural hazards, then the benefits accrue to the profession as a whole. Good will goes a long way in a political setting, and it is important to seize every chance to win some.

## Carrying the Message Forward

Identifying viable political rationales is a first step toward building support for geoscience research in Congress. The remaining steps are directed at using those rationales to build support from policy-makers and their constituents. Here again, the task is no different than making a well-constructed case for a grant. It is not enough to simply state how you plan to spend a sum of money without elaborating on the context, implications, and particularly the significance of the work. Scientists must make that same effort in the policy arena, and that means becoming an active citizen-scientist.

Geoscientists cannot rely on the traditional means of influencing legislation. They do not comprise a sizable voting bloc or make large campaign contributions. Instead, geoscientists must convince policy-makers that their interests are in the

**Destroyed homes in Oklahoma City following Force 5 tornado that ripped through the city on May 3, 1999. The devastation left by the half-mile-wide tornado prompted hearings in the US House of Representatives on improving capabilities for storm prediction and atmospheric research. [photo courtesy of Vicky Fields]**

public interest and that geoscience research represents a public good. As with the economic growth rationale, such arguments are strongest if they come not simply from the scientists themselves but from partners in academia, government, and the private sector. In the case of natural hazards, such partners may include universities, state government, local officials, utilities, insurers, and banks, as well as science and engineering societies. All of these groups are currently involved in some form of advocacy in their own interest. The key is to get them to incorporate support for investment in the geosciences into their advocacy strategy.

Building and maintaining support for the geosciences in Congress is a continual process, and it will be most successful if it is just one component of a broader public outreach and education effort. The long-term vitality of the geosciences depends on the support, not just of Congress and the federal agencies, but of the constituencies which they serve. Fortunately, the geosciences have a strong case to make. All it takes are active citizen-scientists to make it work.

**Scientific organizations such as AGU and AGI are increasingly sponsoring forums on multi-disciplinary topics that have important public policy implications. Above, scientists, economists, and land planners discuss future areas for cooperation and research at a forum on natural disaster reduction held at the American Geophysical Union.**


### Acknowledgments

Portions of this article were adapted from *Geotimes*. More information about the AGI Government Affairs Program can be found at: www.agiweb.org/gap/gaphome.html ■


# Congressional Natural Hazards Caucus

Natural disasters strike every state and nearly every congressional district, thus creating a strong potential for increasing awareness of geoscience issues. Although such broad interest exists, there is no mechanism in place on Capitol Hill to discuss the issues. A congressional natural hazards caucus is one way of creating a forum to address common concerns and maintain continuity of effort.

The proposal for a congressional caucus evolved from a symposium on “Real-time Monitoring and Warning for Natural Hazards” that was sponsored last year by IRIS, the American Geophysical Union, and the American Geological Institute. The meeting was part of the series *Public Private Partnerships 2000 (PPP 2000): Forums on Public Policy Issues in Natural Disaster Reduction* developed by the National Science and Technology Council’s Subcommittee on Natural Hazards Reduction and the Institute for Business and Home Safety. (see IRIS Newsletter Fall/Winter 1998, page 20)

At the symposium, it was recognized that a major challenge in using natural hazards as a compelling rationale for supporting the geosciences is that interest in the events themselves wanes too fast to stay on the political radar. Yet geoscientists must use the heightened short-term interest to explain their relevance. One means of improving the ability to educate Congress about hazards when they arise is through the establishment of a congressional natural hazards caucus.

Because there is first-order agreement that saving lives and reducing property losses from natural disasters is a public good, most programs to reduce losses from natural hazards do not engender the partisan strife that complicates issues such as resource use and the environment. For example, a discussion on the contributions of geology to resource development cannot take place without first engaging in a debate over whether the resources should be developed in the first place. Likewise for most environmental issues. This is not to say that hazards lack contention. When one gets to the specifics of land-use restrictions and insurance premiums, the issues may be just as intractable. But simply being able to get down to the specifics at all is an accomplishment in the political arena.

A congressional caucus could provide an infrastructure for holding congressional briefings or getting information to interested Capitol Hill offices. That is the purpose of caucuses, which are informal organizations consisting of like-minded senators and/or representatives who seek to increase awareness among their colleagues for a particular issue and to provide a forum for discussion. A successful natural hazards caucus would draw upon scientific and engineering societies, the insurance industry, emergency manager groups, and other entities with an interest in reducing the losses from natural hazards. AGI, AGU, and IRIS are currently in the process of meeting with these groups and other organizations to develop support for the caucus. ■

*More information about the Forums on Public Policy Issues in Natural Disaster Reduction can be found at:*
www.usgs.gov/ppp2000/

# Avalanche Hazards in Khibiny Massif, KOLA, and the new Nansen Seismograph Station

***Pavel Chernouss, Yury Zuzin, Evgeny Mokrov [1], Gennady Kalabin [2], Yury Fedorenko [2,3], Eystein Husebye [3]***
***[1] Center of Avalanche Safety of "Apatit" JSC, Murmansk Region, Russia, [2] Kola Science Centre RAS, Russia, [3] Institute Solid Earth Physics, University of Bergen, Norway***

## Background

The Khibiny Mountains in Kola is highly snow avalanche prone during winter with hundreds of avalanches taking place each year. In the pioneering days of mining operations in the Khibiny, which commenced in 1929, the avalanche hazards were largely ignored until a tragic accident on December 5th, 1935 when 88 miners perished near Kirovsk (Figure 1). Avalanche safety measures had already been initiated in 1933, and even at this early stage artificial avalanche release experiments were conducted. The 1935 tragedy triggered more comprehensive safety measures, and various research programs for measurements bearing on physical snow conditions, precipitation, prevailing winds and other meteorological parameters. The ultimate goals of these efforts, dating back to 1935, are enhanced safety measures and avalanche forecasting. The latter goal has proved rather elusive because the avalanche releases are a nonlinear process. Nevertheless, it remains highly relevant today, as skiers 'invade' the Khibiny in winter. In the future, avalanche hazard mitigation will become increasingly important as more skiers and tourists visit the beautiful Khibiny Massif area. The project introduced here aims at physical avalanche modeling with the overall goal of risk mitigation through improved avalanche forecasting.

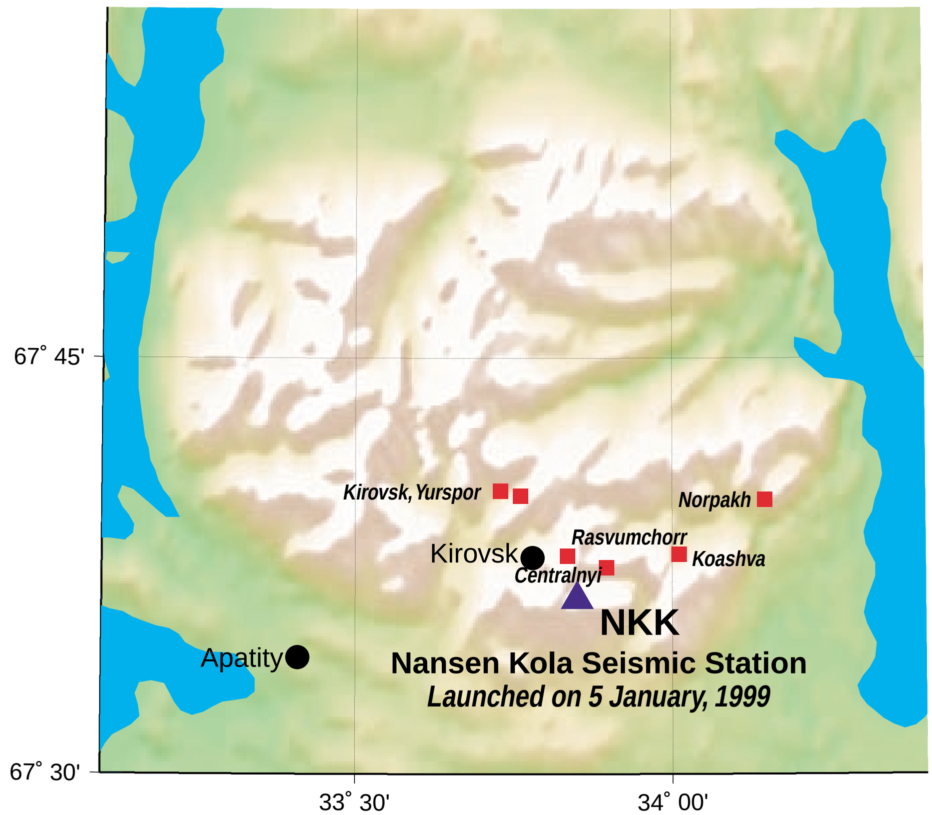



**Figure 1. Topographic map of the Khilbini Massif (elevation step 100m) including locations of major towns, operative mines and naturally the new 3-component Nansen station. NKK is close to several mines and besides offer an unique opportunity to study 3D wavefield responses of rough topography (Hestholm and Ruud, 1998)**

## Seismic loading — artificial avalanche releases

Artificial avalanches can be triggered using dynamite or firing mortar rounds into the 'snow hanging wall'. These techniques are well proven measures for mitigating such hazards. Avalanches may also be released by seismic loading, which in the case of Khibiny, are caused by open pit and underground mine explosions. Over the period 1959–1999, approximately 225 avalanches were triggered in this manner, excluding those released intentionally by *in situ* shootings. (Figure 2) Another example is the large explosion (approximately 100 tons of dynamite) on January 20, 1998, which triggered an avalanche of 40,000 cubic meters directly into the open pit mine Centralnyi. As a result a stretch of a road 600 meters long was buried under thick snow. Even moderate pit mine explosions with charges in the range 10–100 kilograms of dynamite are observed to trigger avalanches at ranges of 2–3 km away from the source, while the larger 10–100 tones explosions can trigger avalanches at least 15 km away.

## The Nansen station — seismic loading monitoring

As previously mentioned, observations indicate that a causal relationship exists between seismic loading and avalanche releases. To model the phenomena, we require a more quantitative relationship, which, in turn, motivated our deployment of the Nansen 3-component station in Khibiny, near the Kirovsk mining town (see Figure 1). The station became operational January 5, 1999 and over 5 months, hundreds of mining explosions

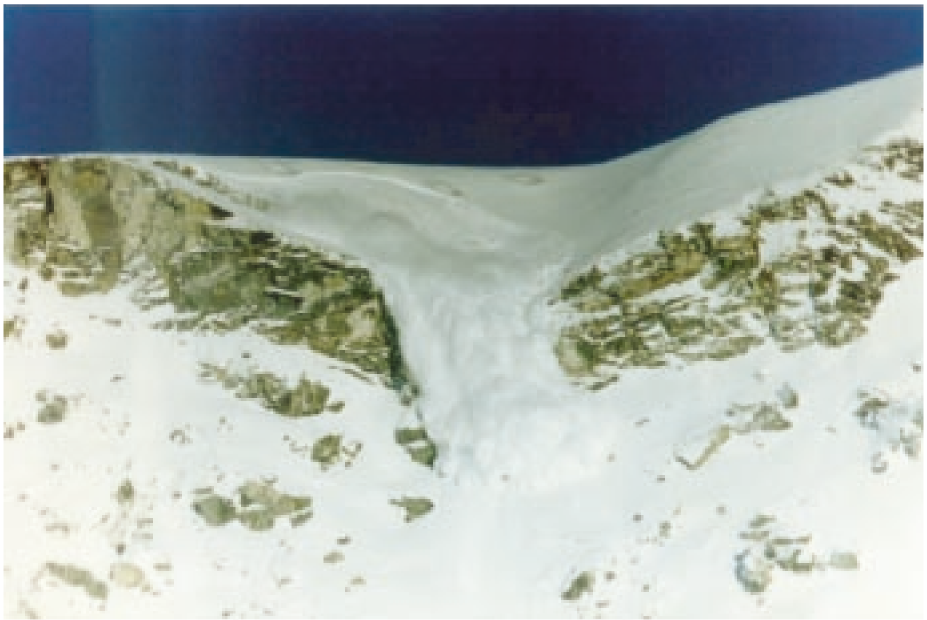


**Figure 2. Artificial avalanche release by mortar firings into the hanging snow wall at the mountain top. The pockmarks indicate the explosion points.**

were recorded. A few recordings from this station are shown in Figure 3. The SP seismometers used ground velocities which were converted to peak ground accelerations (PGAs) and similar measures. The real challenge is to simulate PGAs for an arbitrary explosion over larger Khibiny areas using 3D wave field synthetics, and properly accounting for topographic focusing/defocusing effects (Hestholm and Ruud, 1998).

## Avalanche modeling and forecasting

Several attempts of using avalanche data for statistical forecasting for small areas of the Khibiny have been under taken, but apparently without much success (Chernous and Fedorenko, 1998). Most successful were forecasts of 'avalanche situations' during periods of heavy snow accumulation, implying that some avalanches did occur after delays of 2–4 days — not entirely unexpected. The avalanche database (dating back to 1933) has been subjected to various kinds of multivariate statistical analysis, but it remains somewhat unclear which physical parameters are most diagnostic for avalanche releases. Parallel to these investigations, studies on stochastic 3D models simulating avalanche releases have commenced (Chernouss and Fedorenko, 1998). The data from the Nansen station would be most useful, namely simulating the exceedance (seismic loading) of critical friction force limits in order to initiate an avalanche release.

## Perspectives

Avalanche safety measures are well handled by the Apartity Avalanche Safety Centre of JSC, Kirovsk, but areas of operations are limited to mining towns and their surroundings. Our project aims at avalanche forecasting for larger areas, in particular those popular with weekend skiers. The most difficult part of the project would be to merge wind modeling and snow accumulations with changing snow conditions and avalanche triggering levels into an Avalanche Hazard Model. Our approach would, in some respects, be similar to those used in earthquake risk analysis and prediction. Even if we are only moderately successful, more stations would be deployed for monitoring avalanche occurrences in the Khibiny Massif.

We invite any interested IRIS members to join us in our avalanche monitoring and modeling efforts.

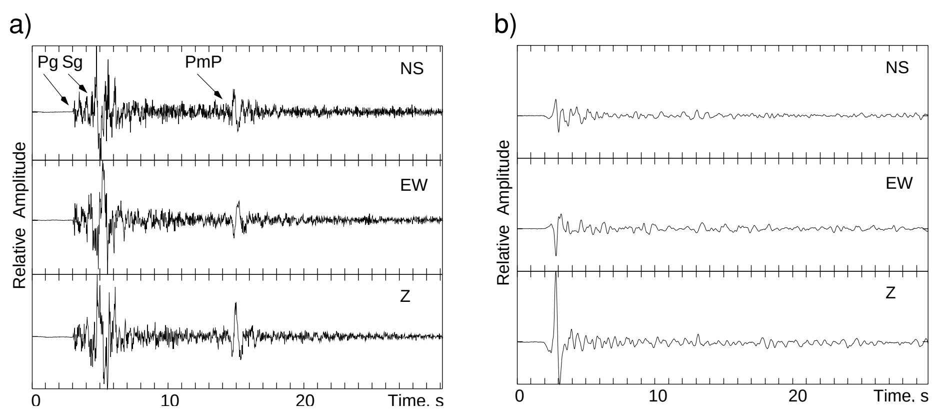



**Figure 3. Nansen station seismograms from a) a local mine explosion (18 km away) and b) a teleseismic event. The presumed PmP-phase in a) illustrate the importance of topography in wavefield modeling. The phase polarization is elliptical, and the amplitude is almost the same at each of the 3 components.**

## Acknowledgments

We express our sincere thanks to the Nansen Foundation, Norwegian Academy of Sciences and Letters, Oslo for the financial support that enabled us to deploy and operate the Nansen station.

## References

P. Chernouss and Yu. Fedorenko, 1998. Probabilistic Evaluation of Snow Slab Stability on Mountain Slopes. *Annals Glaciology*, 26, 303-306.

Hestholm. S and B. O. Ruud, 1998. 3-D finite difference elastic waves modeling including surface topography.*Geophysics*,63, 613-622 ■

# New Format for the Annual IRIS Workshop

Participants at the Eleventh Annual IRIS Workshop

Over 200 seismologists converged in Fish Camp, California for the Eleventh Annual IRIS workshop. With the seismological community buzzing over proposed new initiatives such as EarthScope/USArray, the Plate Boundary Observatory, the Advanced National Seismic System, the new PASSCAL instrument, and the next IRIS five-year proposal, it was a time both to review recent results and to plan our future. Accordingly, the workshop was structured not only with the traditional lecture and poster sessions, but also with a series of discussion groups specifically designed to explore new initiatives and to create a common vision for the future of IRIS. The new format was extremely successful in generating ideas for next IRIS 5-year proposal and in creating a consensus among the IRIS community on future initiatives.

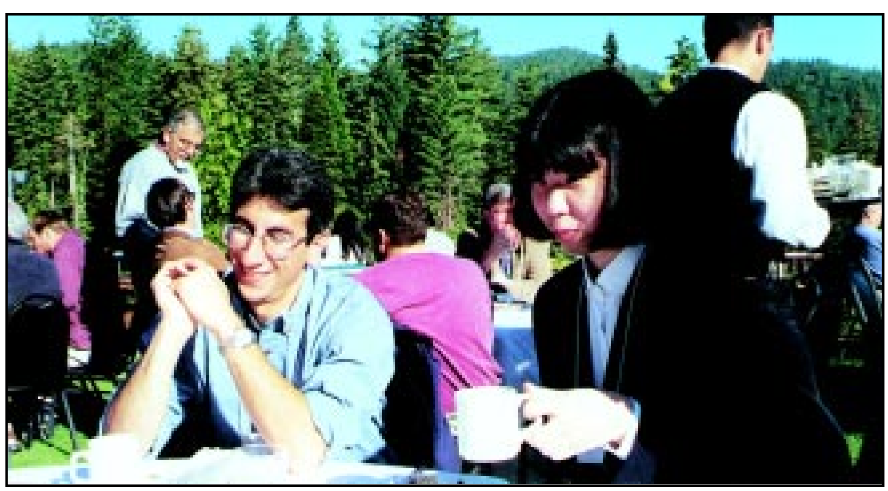
Upon arrival, each workshop participant discovered that they had been assigned to one of five discussion groups. Wednesday evening began with the traditional icebreaker, followed by dinner and a special reception where students and post-docs met each other and learned how they can participate in IRIS programs.

Thursday morning, the workshop began with a lecture session on mountain building organized by Brad Hager. Brian Wernicke discussed the Sierra-Nevada Uplift, Roger Buck described visco-elastic interactions in normal faulting, and Leigh Royden broadened the presentations by outlining the visco-elastic interactions that occur during contraction. After a short break, the session concluded with presentation on the state of the lower crust by Brad Hager; and on crust-mantle interactions by Gene Humphreys.

Following lunch, the Chair of the IRIS Board of Directors, Anne Meltzer, introduced the five discussion group leaders: Art Lerner-Lam, Alan Levander, Jeffrey Park, Gary Pavlis, and Michael Wysession. The groups convened separately for coffee and desert, with their assignment: “Identify and rank the five most interesting scientific questions that seismology can address, and indicate those in which IRIS should play a role.” In the afternoon, a poster session provided opportunity for informal discussions. The day concluded with an Ansel Adams lecture by Robert Woolard, dinner in the lodge, and brief presentations by the group leaders from the afternoon discussions.

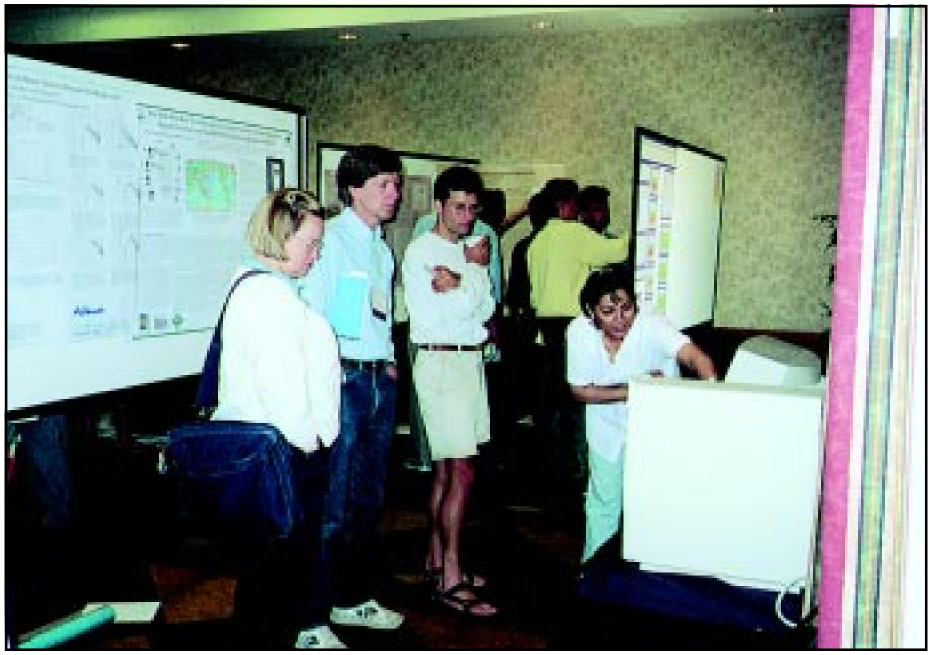
On Friday morning, Anne Meltzer summarized the results from the discussion groups (see box). There was remarkable similarity in both the views and priorities presented by each of independent discussion groups. Encouraged by the apparent consensus within the workshop, the groups were then tasked with the follow-up question: “How can we best attain our IRIS-related goals within the context and time-frame of our next 5-year proposal?”

A series of lectures on the lower mantle organized by Michael Gurnis then began. Lianxing Wen spoke about



Participants enjoyed the beautiful weather during mealtimes.

the fine seismic structure of the lowermost mantle; Quentin Williams discussed the lowermost mantle and evidence for magma oceans and the source of hotspots; and Guy Masters spoke about the imaging of chemical and thermal anomalies. Following the break, Lars Stixrude discussed the role of mineral physics as the link between seismology and dynamics; and Igor Sidorin reconciled the seismic observations, models, and mineral physics for the base of the mantle. The lecture session convened promptly at noon as everyone grabbed boxed lunches and many headed off to hike through Yosemite National Park. Following dinner that evening, the discussion groups reconvened to develop specific recommendations for the next IRIS 5-year proposal.



**Poster sessions provided opportunity for informal discussion and planning.**

On Saturday, the group leaders presented their final reports for the IRIS proposal. Once again, there was considerable consensus about the future role of IRIS and direction of our various programs. Many of the recommendations fell within the themes of increasing resolution, bandwidth, coverage, and stability. There were also calls for improvements in data accessibility; development of the new PASSCAL instrument; coordinated software development, promotion of new initiatives such as USArray and the Plate Boundary Initiative; expanded earthquake studies; and the use of the Consortium as an organizing structure for the seismological community and as representatives within Washington for the greater Geoscience community.

Following the discussion group reports, a lecture session organized by Tom Jordon on the science of earthquakes began. Göran Ekström presented a talk on global seismicity; Greg Beroza discussed regional studies of earthquakes; Mark Zoback discussed local studies of earthquakes; and James Deterich gave a talk on laboratory studies of earthquakes. The session ended at noon.

Following lunch, representatives from the National Science Foundation discussed the EarthScope proposal and answered questions from workshop participants. The workshop ended with a barbecue dinner and an astronomy presentation by Fresno State.

We extend a special thanks to the workshop organizers John Vidale and Gene Humphreys, the session chairs, Brad Hager, Michael Gurnis, and Tom Jordon, and a special thanks to the discussion group leaders: Jeffrey Park, Art Lerner-Lam, Alan Levander, Gary Pavlis, and Michael Wysession. ■

## The most interesting questions that seismology can address

*(according to participants of the Eleventh Annual IRIS Workshop)*

- ❖ What are the interactions between lithosphere and the underlying mantle? How are these interactions expressed at the Earth's surface?
- ❖ How do the core and mantle affect each other?
- ❖ How well mixed is the mantle?
- ❖ What is the seismicity and tectonics of terrestrial planets?
- ❖ What is the vertical distribution of anisotropy in the upper mantle and crust? How does anisotropy relate to flow?
- ❖ What is the shape and origin of plumes?
- ❖ How do fluid and magmatic processes enable tectonics?
- ❖ What causes the initiation and termination of earthquake rupture?
- ❖ Do small earthquakes relate to large earthquakes?
- ❖ To what extent are earthquakes physically independent?
- ❖ What is the fine structure and organization of fault systems?
- ❖ What role does non-linear dynamics play in Earth processes?
- ❖ How does ground motion behave at the fine scale?
- ❖ What signals are we not observing?

# Seismologists Learning to Teach the Teachers

## IRIS Education and Outreach Workshop
## Yosemite, June 1999

The IRIS Education and Outreach program held a one-day workshop in Yosemite aimed at helping seismologists prepare to run a workshop at their home institution for local K–12 teachers. The workshop goals were to (1) involve participants in hands-on and inquiry-based activities that can be used to teach seismology and related Earth Science, (2) provide background on current issues in K–12 science education and on the K–12 classroom environment, and (3) provide information on the logistics of running a teacher workshop. The workshop, organized by Larry Braile (Purdue University), Sheryl Braile (Happy Hollow Elementary School), Rob Mellors (San Diego State University), and Catherine Johnson (IRIS), was attended by 14 people from a variety of colleges and universities.

**Prior to the IRIS Workshop, seismologists learned exercises and activities for teacher workshops, including participating in a contest in which they designed earthquake-resistant buildings.**

An introductory quiz on K–12 education statistics got everyone on their feet and temporarily away from the coffee and donuts. (What percentage of K–12 teachers are female? — answer at the bottom of the page). The rest of the day focussed on activities to use in a teacher workshop. Participants made slices and 3-D models of the Earth (activities designed to teach about internal structure), and simulated the construction of travel-time curves and earthquake location through a walk-minus-run-time activity carried out under beautiful clear Yosemite skies. Other activities included demonstrations of an epicenter plotting exercise, a plate tectonics flip-book (home-grown substitute for computer simulations of plate motions), and a plate tectonics CDROM. In IRIS-run K–12 teacher workshops, we also spend some time in a lecture/demonstration mode to provide participants with background information and materials on plate tectonics and earthquakes. A brief synopsis of this lecture material was given. The final activity was a contest in which participants designed earthquake-resistant buildings. Testing of the structures on a shake table revealed that our group of experts would provide sound advice to a building safety commission!

In addition, Larry Braile gave a presentation on the status of US education. We hear many, often conflicting, reports on the television and in the newspapers about the state of US education, in particular science and math education. Much of the information and the way in which it is presented can be misleading. Larry discussed some of the current controversial issues and the data sets on which broad political statements are based.

Follow-up will involve each participant running a 1–day workshop for teachers in their local area during the next academic year. IRIS Education and Outreach provides support and materials for these workshops. Jeff Barker who attended a similar workshop in 1997 has since run two teacher workshops and provided encouraging “testimony”. Taking our science (and where possible our own individual research) beyond our university and peers is our responsibility as scientists. Short, teacher workshops are effective, do not demand excessive time, and last but not least are extremely rewarding. We encourage all IRIS members to participate in the workshop program. ■

**Workshop Participants**

| | |
|---|---|
| John Craddock | Macalester College |
| Kazuya Fujita | Michigan State University |
| Katrin Hafner | California Institute of Technology |
| Alan Kafka | Boston College |
| John Lahr | US Geological Survey |
| Tim Long | Georgia Institute of Technology |
| Elizabeth Meyers | University of Alaska, Fairbanks |
| Jim O’Donnell | University of Nevada, Las Vegas |
| Wayne Pennington | Michigan Technological University |
| Gerry Simila | California State University, Northridge |
| Gregory van der Vink | IRIS |
| Frank Vernon | University of California, San Diego |
| Lisa Wald | US Geological Survey |

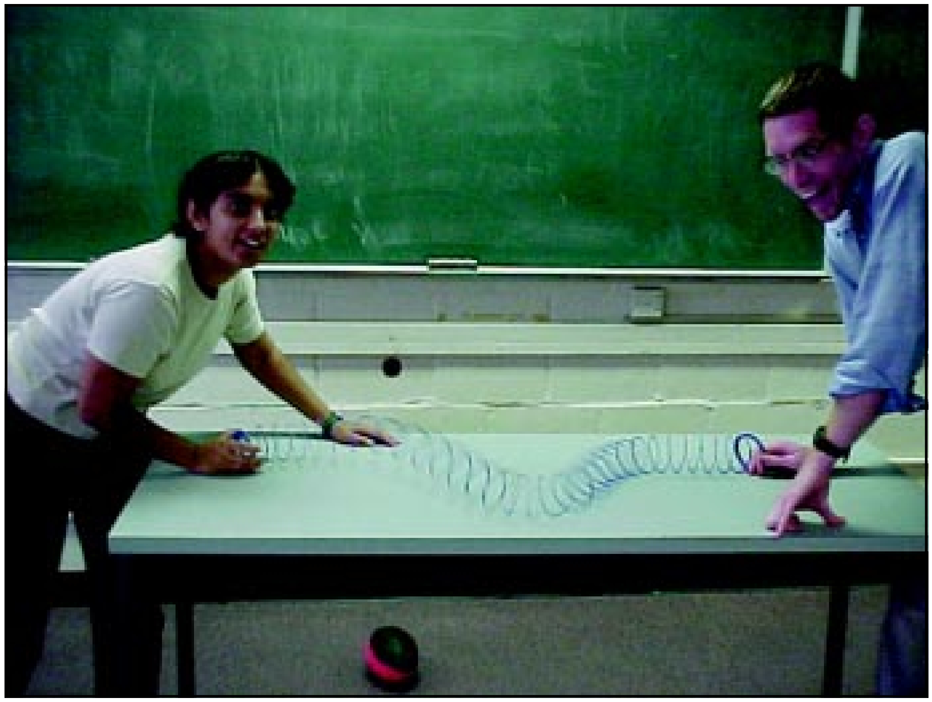
*75% of K-12 teachers are female, 85% of elementary school teachers are female.*

# Teach For America Intern at IRIS

***Bella Desai, Teach For America***

My first encounter with IRIS happened while I was waiting outside Jeffrey Park's door during his office hours for Geology & Geophysics 120 at Yale. I was a freshman, enrolled as a "probable" English major, taking the class to fulfill my natural science requirement. The student before me was taking a long time, so my eyes naturally wandered around the Kline Geology Lab corridor and settled on a fetching poster of travel time curves. And there it was, in the lower right hand corner, in stately font topped with an elegant seismic trace, "the IRIS consortium." I thought, "Cool logo."

Little did I know that three months later I would find myself "trying out the research thing," wrestling with Fortran and downloading seismic data from the IRIS DMC and SPYDER®. When I decided that a second major in History would complement "the Geophysics thing," I didn't know that IRIS would become the focus of my History thesis. And certainly, when I abandoned Geophysics and History altogether at graduation to do Teach For America, I didn't realize I would be working as an IRIS intern the following summer. IRIS follows me around like the moon.



**Bella Desai (left) and fellow Teach For America corps member demonstrate an activity designed to teach about seismic waves.**

In this latest encounter, I have been working to fortify the .edu in IRIS's domain name. During the school year, I am a second grade teacher in East Palo Alto, California. I have been working this summer to bring earthquake science to elementary students such as my own. I believe that if seismology as a field is to continue flourishing, we need to educate not only those select few who will eventually become seismologists, but also every one else, who will foot the bill. We all know, as scientists, the importance of basic research in seismology as an end in itself. We need to instill this value in the public. Every child in elementary school is taught and learns to appreciate art, music, and sports. Only a tiny fraction of children will ever become professional artists, musicians, or athletes, but almost all of them will grow to feel that these fields are inherent in a civilized society. It is difficult to feel that basic seismology research is inherent in today's civilized society if you don't even know what "seismology" means. This summer, I have created elementary, middle, and high school lesson plans to support IRIS's upcoming display in the American Museum of Natural History Discovery Room. I have also created a set of second grade lessons that are an extension of a standard language arts curriculum used widely throughout California. By integrating seismology directly into language arts, I hope to make it easier for teachers to bring seismology into their classrooms.

As I prepare to head back to school this fall, I leave with a stack of lessons and ideas under my arm. My goal as a Teach For America teacher is to provide students in under-resourced areas with the opportunity to attain an excellent education. As I return to fulfill the second half of my two-year commitment, I feel confident that this joint internship between Teach For America and IRIS will help me reach that goal. Perhaps I will meet a elementary student someday who has used the integrated curriculum or done a workshop at the museum. Maybe she will show me the different waves in the seismic trace above the purple IRIS letters on the corner of a poster. And then I'll think, "Cool logo." ■

*For more information about Teach For America and how to apply, call (800) 832-1230 or visit their web site www.teachforamerica.org* ■

# IRIS Brings Seismology to Capitol Hill

Members of Congress and their staff created earthquakes, saw a playback of the 1994 Northridge event, and learned about global seismology at an exhibition and reception on Capitol Hill organized by the Coalition for National Science Funding. The exhibition featured projects supported by the National Science Foundation and demonstrated to Congress how such projects meet the nation's research and education goals.

At the invitation of the American Geological Institute and the American Geophysical Union, IRIS set up a seismology display that was developed with the US Geological Survey. Members of Congress appreciated the strong cooperation between IRIS and the US Geological Survey. They were impressed also with the multiple uses of the IRIS facilities — serving not only scientific research, but also earthquake hazards, nuclear monitoring, and education. Other exhibits included "The Virtual Earth System" by the University Corporation for Atmospheric Research and "Measuring the Earth with Quasars" by the American Astronomical Society.

**David Applegate, Director of Government Affairs for the American Geological Institute, discusses recordings from the Northridge earthquake at the Coalition for National Science Funding exhibition on Capitol Hill.**

Following the exhibition, Congressman F. James Sensenbrenner, Jr., Chairman of the Science Committee, issued a statement commenting "I am among those constantly amazed by the variety and depth of NSF-sponsored projects, some of which are on display today.... While other federal science agencies may have bigger budgets, I doubt if any has a bigger impact than the National Science Foundation (NSF) on the scientific enterprise."

At the AGU/AGI/IRIS exhibit, most of the questions were about earthquake hazards and the frequency of earthquakes in various parts of the world. Such questions were no doubt partly due to the timeliness of the exhibit — following the recent passage of the Earthquake Hazards Reduction Authorization Act of 1999. The bill authorizes a total of $469.6 million over five years for the National Earthquake Hazard Reduction Program (NEHRP), and includes funding for the Advanced National Seismic System. Although the authorization passed strongly, the tight budget climate may make it difficult for the funds to be actually appropriated this year. ■

## The Consortium of Organizations for Strong Motion Observation Systems (COSMOS)

***Bruce A. Bolt, President, COSMOS***

An agreement has been reached to form a public benefit nonprofit corporation entitled, "Consortium of Organizations for Strong-Motion Observation Systems." (COSMOS) The decision was taken based on a Charter agreement between the California Strong Motion Instrumentation Program, the US Geological Survey, the US Bureau of Reclamation, and the US Army Corps of Engineers. The sponsoring organization is the US Committee for the Advancement of Strong Motion Programs (CASMP) funded by the National Science Foundation (NSF).

The purposes of the Corporation as defined by the COSMOS Charter are as follows:

1. Develop policies and foster innovative ideas for the urgent improvement in the strong-motion measurement and their applications;

2. Promote the advancement of strong-motion measurement in densely urbanized areas and other locations of special significance to society likely to be struck by future earthquakes;

3. Encourage and assist the rapid, convenient, and effective distribution of strong-motion data according to COSMOS standards;

4. Strengthen, expand, and support strong-motion programs;

5. Serve as a consortium through which programs and institutions can work to solve mutual problems with instruments, data and its dissemination, and data utilization; and

6. Advance systematic user influence on data acquisition and data dissemination processes. ■

*For more information see website: www.cosmos-eq.org/default.html*

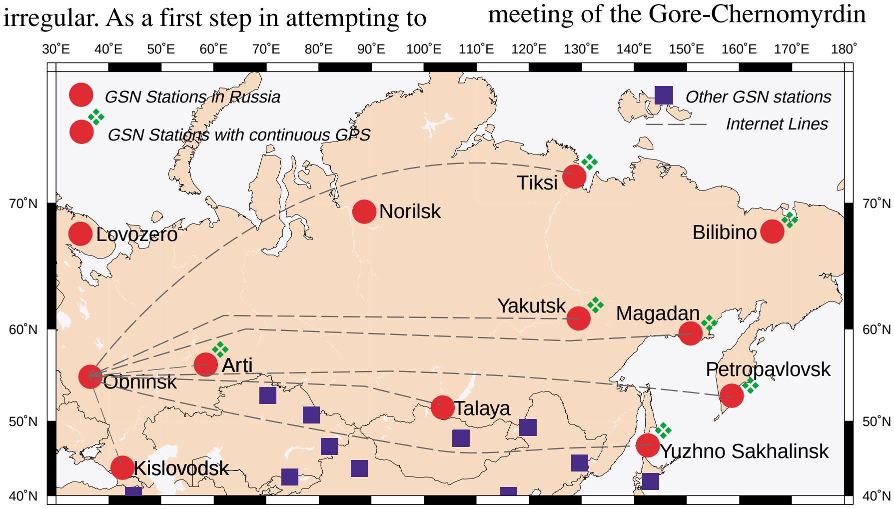
# Agreement Signed on US Russian Cooperation in Observational Seismology and Geodynamics

The twelve Global Seismographic Network stations in Russia add significantly to data for global seismology, providing information from a broad region of Europe and Asia that had previously been closed to western observers. Since the breakup of the Soviet Union, there have been numerous changes in the mode of operation of the Russian GSN stations. Largely due to the excellent cooperation between the Geophysical Service in Obninsk, the GSN networks operators (UCSD and ASL) and individual station operators, the Russian stations have continued to work unabated, and in many ways have improved, during the dramatic changes in Russia over the past decade. Internet has been added to most of the stations, providing near real-time access to data. GPS instruments have been added at a number of sites.

**Signatories to the Agreement: Director of the US Geological Survey, Chip Groat; Director of the National Science Foundation, Rita Colwell; Minister of Science and Technologies, Mikhail Kirpichnikov; and Vice President of the Russian Academy of Sciences, Nikolai Laverov. Assisting in the signing ceremony are Laura Efros from the Office of Science and Technology Policy and Vladimir Tychtchenko of the Ministry of Science and Technologies.**

One perpetual source of problems has been relations with the Russian customs service. The agreement under which the GSN stations were originally installed in Russian was with the Soviet Academy of Sciences. Import of GSN equipment and supplies was through the Academy and it was relatively easy for all scientific materials to be declared exempt from duties and taxes. Under the new regime, import regulations have changed dramatically and customs control has become much more complex and irregular. As a first step in attempting to re-formalize the GSN project and solve the customs problems, it was clear that a new agreement was required.

Many of the high level agreements for scientific cooperation with Russia are now carried out under the bilateral exchanges coordinated by US Vice-President Gore and the Russian Prime Minister (originally the Gore-Chernomyrdin Commission). At the Science and Technology Commission meeting of the Gore-Chernomyrdin Commission in January 1996, a Memorandum of Understanding on Observational Seismology was signed that eventually lead to a full Agreement prepared for the Gore-Primakov Commission in March 1999. Although the Kosovo crisis lead to the abrupt cancellation of the full Commission meeting, the Science and Technology Committee did meet and approved the Agreement which was signed on March 24, 1999.




While signatures on a formal document are a significant and important step, the real work of ensuring the long-term, stable operation of the GSN stations in Russia continues to be a challenge. Problems with customs remain, especially in the remote areas of the far eastern regions. The financial situation in Russia has placed serious constraints on the support of their scientific infrastructure. The contributions to international seismology, through the dedicated work of the individuals at each of the Russian stations, is greatly appreciated. ■

# IRIS/USGS Expand Museum Program

In partnership with the US Geological Survey, IRIS is expanding its museum program. In addition to the prototypes that are currently at IRIS headquarters in Washington, DC, the New Mexico Museum of Natural History in Albuquerque, NM, and the Franklin Institute Science Museum in Philadelphia, PA; additional exhibits are being developed at the Carnegie Museum of Natural History in Pittsburgh, PA, and the American Museum of Natural History in New York, NY. Within the next six months, we expect the display program to reach an audience of approximately 8.75 million each year. With expansion of the program to include two or three additional museums over the next few years, the total audience for the full program could be as high as 10 million per year.

## Display Concept

Most people are amazed to learn that an earthquake occurred today; and they are astonished to discover that earthquakes are continually occurring. In general, the public views earthquakes as unusual events that result in cataclysmic destruction. We have developed exhibits with the above-mentioned museums to change the public perception of earthquakes. We present earthquakes not as destructive events, but rather as signals of the dynamic geological forces that build our mountains and create our ocean basins. In other words, we seek to develop an appreciation for earthquakes as nature's reminder that we are living on the thin, outer crust of a planet whose interior is still cooling.

By bringing live seismic data over the Internet and broadcasting it in museums, we provide visitors with evidence that the Earth's surface is in motion. The displays and accompanying educational materials show why earthquakes occur, how seismometers record earthquakes, how earthquakes relate to plate tectonics, and how we can use seismology to explore the Earth's interior. The displays use earthquakes to capture the visitor's attention, but they also use earthquakes as an introduction for a broad range of Geoscience concepts.


Newsday
THE LONG ISLAND NEWSPAPER
COVER STORY
Journey to the
Center Of The Earth
Museum takes an inside look at home, exotic home

The IRIS/USGS seismology display is reported to be one of the most popular exhibits within the American Museum of Natural History's Hall of Planet Earth.

In meeting with museums, we discovered that approximately 40% of their visitors arrive in groups, usually as part of a school trip. To host these groups, museums are creating "classrooms" and developing demonstrations. For such classrooms, we are including within the museum display the ability to playback famous earthquakes. Museums will, for example, be able to replay the Northridge earthquake and set the display to record ground motion as it would appear at different seismic stations across the United States. Visitors see, for example, that stations close to the


**In addition to the new Hall of Planet Earth, IRIS and the USGS are developing exhibits and demonstrations for the teaching Halls at the American Museum of Natural History in New York.**

earthquake record P-waves and S-waves in quick succession; but with increasing distance from the earthquake the time differences between the arrival of the P-waves and S waves increases. Accompanying handouts and classroom exercises will translate this observation into an understanding of how we are able to determine the location of an earthquake from seismic records.

### A Launching Point for Further Interest in Geoscience

The museum display is designed as a launching point for further understanding of seismology and Geoscience. In fact, all of the educational content of the display can be "carried away" with the visitor. In addition to the one-pagers, posters, and teaching exercises, the electronic portions of the exhibit are accessible through accompanying websites that allow individuals or classes to continue to monitor global seismicity in their classrooms or homes. The website displays are interactive and allow viewers to find out more information about individual earthquakes, to access actual ground motion records from various seismic stations, and to electronically visit individual seismic stations around the world.

### Further expansion

The display concepts are continually evaluated through a variety of forums, including scientific conferences, Earth Science Week programs, and Congressional exhibits. We expect that most of our recommendations, however, will come from museums that have been testing the prototype that is touring across the country as part of the Franklin Institutes **Power of Nature** exhibit. Videotape records of viewer response and interview evaluations provided by the various museums will be used to improve the concepts of the display.

If you know of other museums that would be interested in developing real-time earthquake exhibits, please contact the IRIS Education and Outreach Program. ■

**The "make-your-own-earthquake" display captures the attention of visitors, and prompts them to learn more about the relationship of earthquakes to plate tectonics.**

## EarthScope News

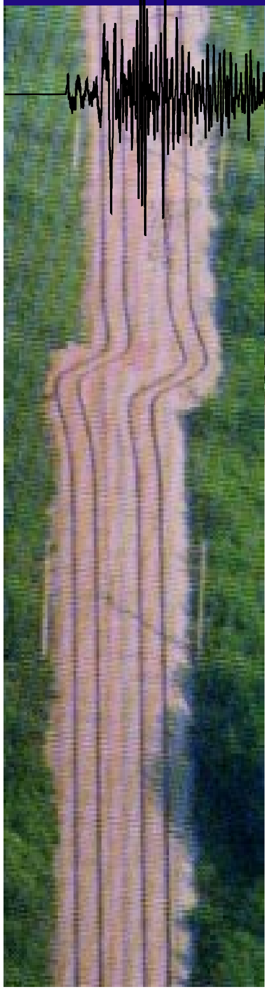
There are exciting developments at the National Science Foundation (NSF) related to a major new facilities initiative called "EarthScope: a Look into our Continent". The Earth Science Division at NSF is working with a number of organizations representing the research community to develop a plan to be presented to the National Science Board later this year for consideration as a Major Research Equipment (MRE) initiative. The MRE account is an NSF-wide program to provide funding for the construction and acquisition of major facilities that are beyond the funding resources of any one Directorate.

Two of the components of EarthScope, USArray and the Plate Boundary Observatory (PBO) were described in the last IRIS Newsletter. SAFOD (San Andreas Fault Observatory at Depth) was described in the Fall 1993 issue of the IRIS Newsletter. USArray and SAFOD are included as the first two components of the EarthScope initiative which has received strong support as it begins to move through NSF. PBO and related facilities for satellite interferometric synthetic aperture radar (InSAR) will be proposed as a future component of EarthScope.

The USArray component of EarthScope is being presented to NSF as a significant enhancement to facilities for portable seismic instrumentation for use in investigations of the structure, evolution and dynamics of the North American continent. At the same time, the Advanced National Seismic System (ANSS) has been authorized, as part of the National Earthquake Hazards Reduction Program, as a USGS initiative to improve facilities for permanent seismic networks for earthquake monitoring. IRIS and NSF are working closely with the USGS to coordinate the development and implementation of these two complementary facilities for a broad spectrum of seismological studies.

Information on EarthScope will be available through the IRIS website and www.EarthScope.org. Articles on USArray have been published in EOS (June, 1999) and GSA Today (November, 1999). Reports from recent workshops on USArray and PBO will be posted. A USGS report on ANSS is being published as USGS Circular 1188 and is also available through http://geohazards.cr.usgs.gov/pubs/circ. ■

# This Issue's Bannergram




The seismogram above (and on page 1) is a broadband, vertical component recording of the Magnitude (Mw) 7.4 earthquake that devastated parts of western Turkey on August 17, 1999. The recording shows the ground motion at the IRIS GSN station KIV near Kislovodsk, Russia, about 1,000km northeast of the earthquake epicenter.

Loss of life and damage to structures were massive. More than 15 thousand people were killed in the earthquake, over 24 thousand injured. The estimated total economic loss due to the earthquake exceeds $16 billion. Collapsed and damaged buildings alone amount to over $5 billion. Most damaged structures were 4-8 story reinforced concrete buildings such as the one shown in the photo above. The technical causes that contributed to the observed damage to buildings include poor concrete quality, poor detailing of reinforcements, and structural alterations.

The earthquake occurred along the northern strand of the North Anatolian Fault Zone (NAFZ), one of the best studied strike-slip faults in the world. According to reports from Turkish and USGS field crews, the main shock produced more than 100 km of surface rupture. Right-lateral offsets as large as 5 meters were observed along the entire length of the rupture. In the photo (left) railroad tracks running between the cities of Izmit and Arifiyi are offset by 2.7 meters.

The NAFZ is known as the most prominent active fault in Turkey. Since 1939, the NAFZ has produced seven earthquakes with magnitudes (Ms) larger than 7.0. These earthquakes have ruptured the fault progressively from east to west, creating distinct regions of enhanced stress levels. In 1997, a study of stress changes along the fault estimated a 12% probability that within the next 30 years a major earthquake may occur in the region of the NAFZ now effected by the August 17 earthquake.

For more information and data from the earthquake, please visit our special event page on the Turkish earthquake at www.iris.edu ■

# Staff News

The IRIS Data Management Center was happy to welcome Mary Edmunds to the staff in July, 1999, as a Data Control Technician. Mary is from the Seattle area, and was previously working for the University of Washington. She has a background in the Earth sciences and has been a very welcome addition to the group that archives and processes the large number of requests that come through the Center.

We want to congratulate Chau Tran and Christina Jenkins in the IRIS business department. Both delivered beautiful babies this summer. Chau's family has another baby girl, Hien; and Christina delivered her first baby, Benjamin. All are doing well. ■

# IRIS Newsletter

published 2 times per year by the IRIS Consortium.
Please address your letters or inquires to:

IRIS Newsletter
1200 New York Avenue, Suite 800 Washington, DC 20005
Phone: 202-682-2220 Fax: 202-682-2444 www.iris.edu

the IRIS CONSORTIUM

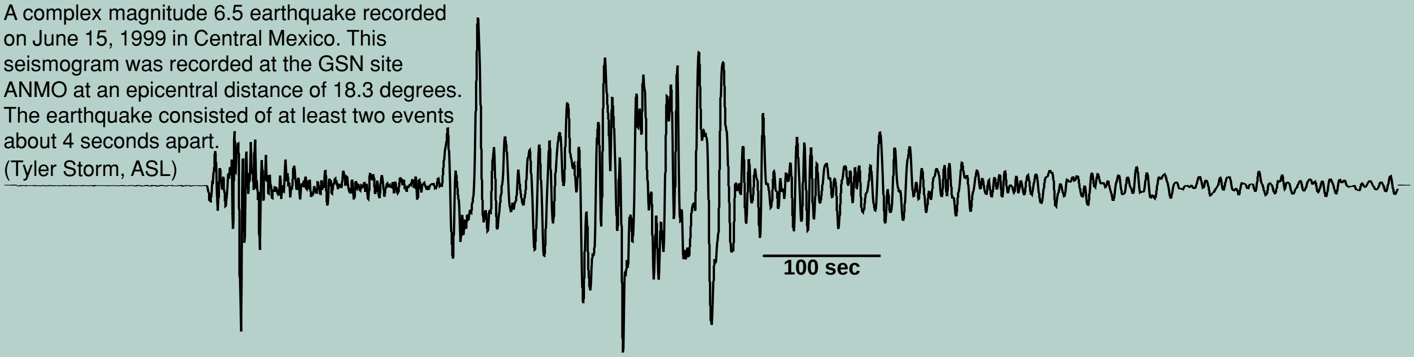
The Incorporated Research Institutions for Seismology (IRIS) is a university consortium of over 90 research institutions dedicated to monitoring the Earth and exploring its interior through the collection and distribution of geophysical data. IRIS programs contribute to scholarly research, education, earthquake hazard mitigation, and the verification of the Comprehensive Test Ban Treaty. IRIS operates through a Cooperative Agreement with the National Science Foundation under the Division of Earth Science's Instrumentation and Facilities Program. Funding is provided by the National Science Foundation, the Department of Energy, the National Imagery and Mapping Agency, other federal agencies, universities, and private foundations. All IRIS programs are carried out in close coordination with the US Geological Survey and many international partners.

The IRIS Newsletter welcomes contributed articles. Please contact one of the editors or send your submission to the address above.

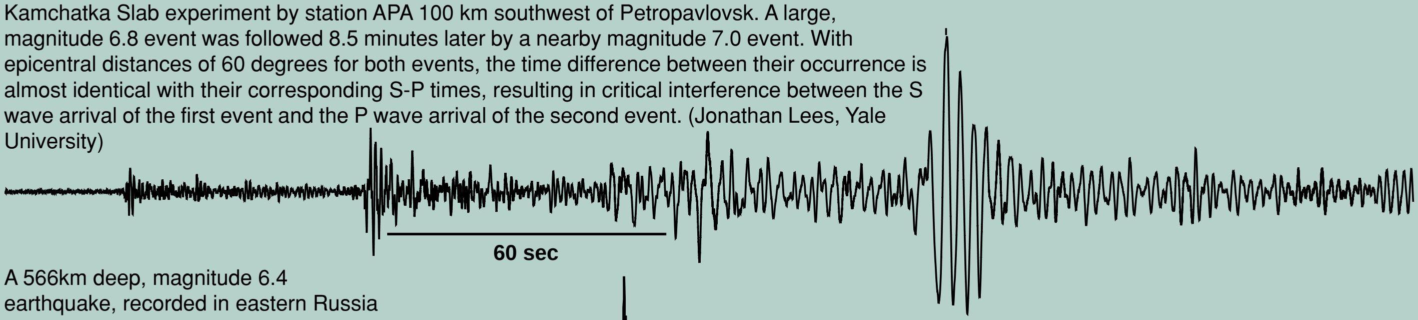
Editor-in-Chief:
David Simpson
(simpson@iris.edu)

Executive Editor:
Gregory van der Vink
(gvdv@iris.edu)

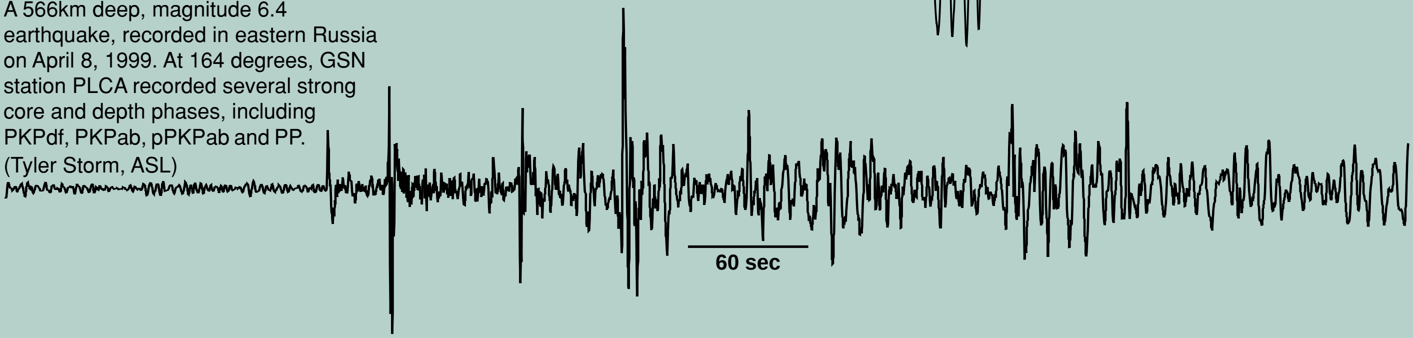
Production Editor:
Anne DeLaBarre Miller
(anne@iris.edu)



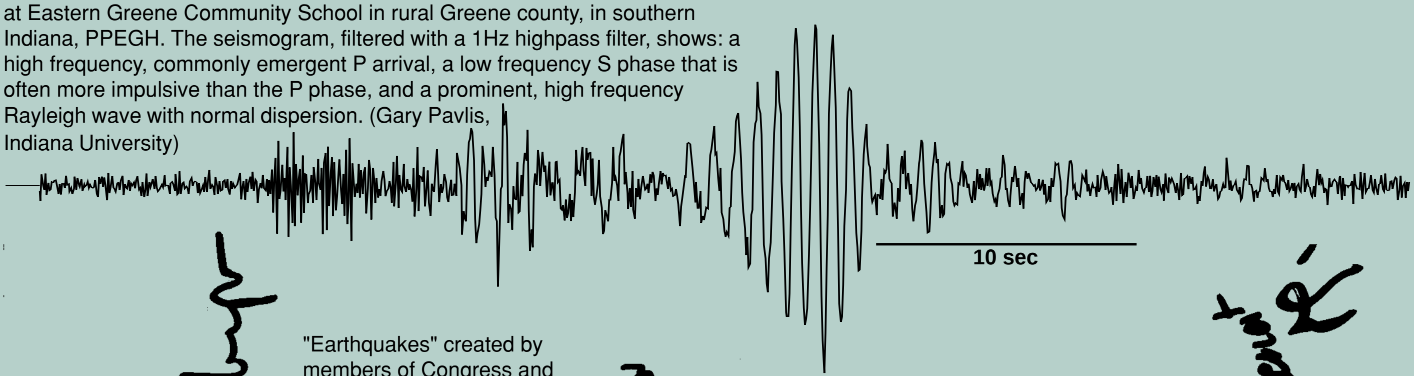

A complex magnitude 6.5 earthquake recorded on June 15, 1999 in Central Mexico. This seismogram was recorded at the GSN site ANMO at an epicentral distance of 18.3 degrees. The earthquake consisted of at least two events about 4 seconds apart. (Tyler Storm, ASL)



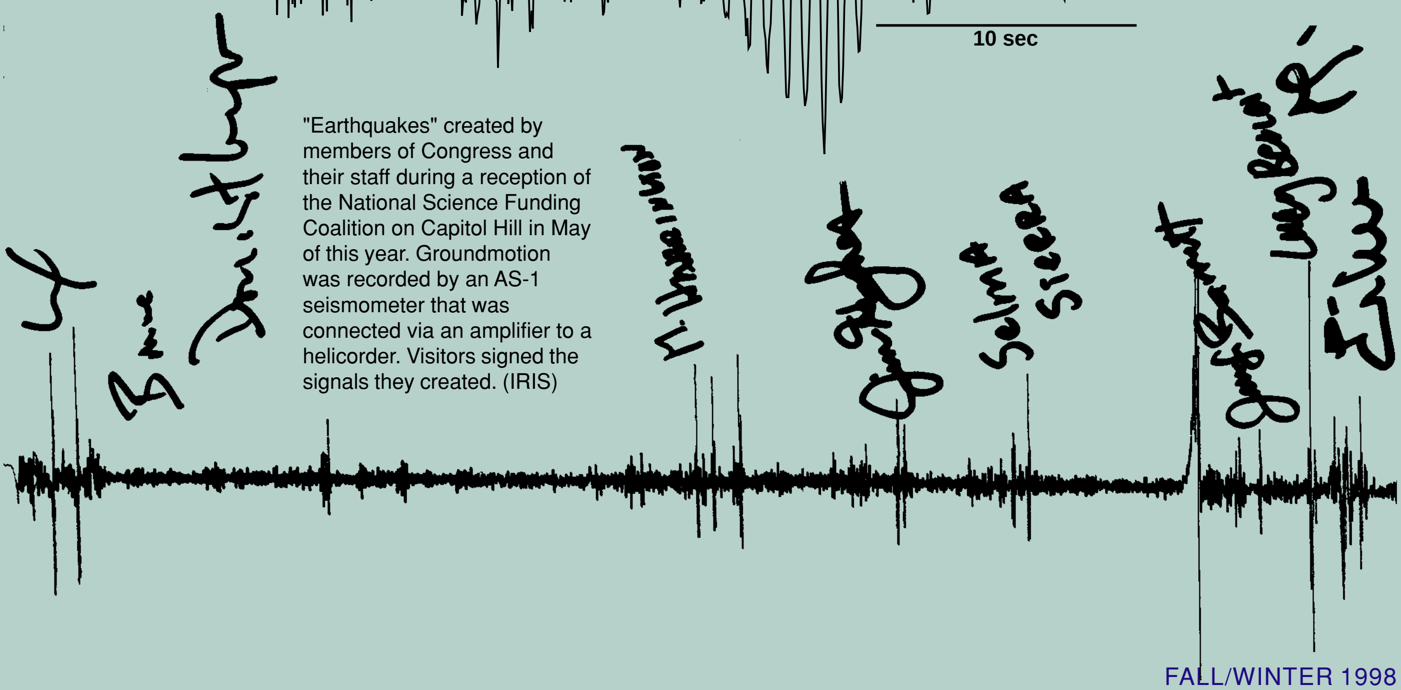

Two Banda Sea earthquakes recorded on November 9, 1998 in Kamchatka. The data were recorded with an excellent signal-to-noise ratio on PASSCAL instruments during the Site Edge of Kamchatka Slab experiment by station APA 100 km southwest of Petropavlovsk. A large, magnitude 6.8 event was followed 8.5 minutes later by a nearby magnitude 7.0 event. With epicentral distances of 60 degrees for both events, the time difference between their occurrence is almost identical with their corresponding S-P times, resulting in critical interference between the S wave arrival of the first event and the P wave arrival of the second event. (Jonathan Lees, Yale University)




A 566km deep, magnitude 6.4 earthquake, recorded in eastern Russia on April 8, 1999. At 164 degrees, GSN station PLCA recorded several strong core and depth phases, including PKPdf, PKPab, pPKPab and PP. (Tyler Storm, ASL)




A typical mining explosion recorded on a vertical component PEPP instrument at Eastern Greene Community School in rural Greene county, in southern Indiana, PPEGH. The seismogram, filtered with a 1Hz highpass filter, shows: a high frequency, commonly emergent P arrival, a low frequency S phase that is often more impulsive than the P phase, and a prominent, high frequency Rayleigh wave with normal dispersion. (Gary Pavlis, Indiana University)



"Earthquakes" created by members of Congress and their staff during a reception of the National Science Funding Coalition on Capitol Hill in May of this year. Groundmotion was recorded by an AS-1 seismometer that was connected via an amplifier to a helicorder. Visitors signed the signals they created. (IRIS)

# CALENDAR

## 1999

**October 17-20**
Eastern SSA
Memphis, TN

**December 13-19**
AGU
San Francisco, CA

**December 13**
Board of Director's Meeting
Yank Sing, San Francisco, CA

## 2000

**May 7-11**
IRIS Workshop
Samoset, Rockport, ME

**May 30-June 3**
Spring AGU
Washington, DC

**June 18-23**
9th International Symposium on Deep Seismic Profiling of the Continents and their Margins
Ulvik, Norway

# NEW MEMBERS

IRIS welcomes as a Foreign Affiliate: Kuban State University, Krasnodar, Russia; Vladimir A. Babeshko, representative. ■

# 12th Annual IRIS Workshop

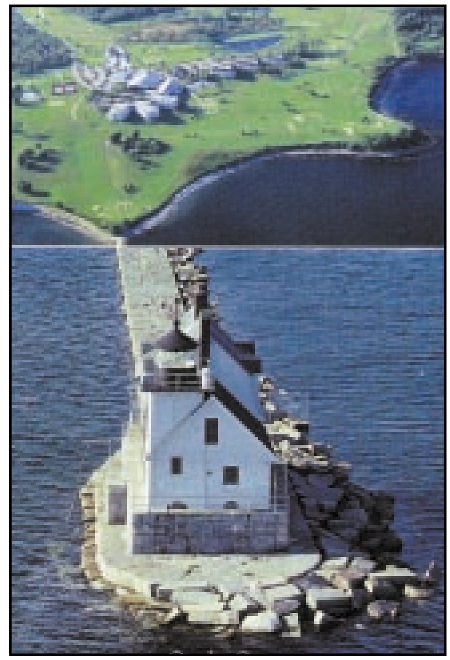
**May 7-11, 2000**
**Samoset Resort**
**Rockport, Maine**

The 12th Annual IRIS Workshop will be held May 7-11 at Samoset Resort, in Rockport, Maine.

Samoset offers great meeting facilities as well as many recreational activities. Bar Harbor and Acadia National Park are popular destinations to the North. There are also lighthouses, museums and theaters to enjoy and an ocean of beauty, sailing and fishing opportunities. Samoset Resort is located 2.5 hours north of Portland, ME.

For more information on Samoset, see their website: http://www.samoset.com/

Please watch for registration information in the mail and on our website. ■




the IRIS CONSORTIUM
1200 New York Avenue, NW
Suite 800
Washington, DC 20005


Address Correction Requested

NON PROFIT ORG.
US POSTAGE
PAID
WASHINGTON DC
PERMIT NO 1227